NON-HETEROMORPH AMMONITES FROM THE UPPER MAASTRICHTIAN OF PONDICHERRY, SOUTH INDIA

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ABSTRACT. The Phylloceratina, Lytoceratina and Ammonitina of the upper Valudavur Formation (Valudavur Group or *Anisoceras* Beds of authors) collected near Pondicherry, south India, are revised on the basis of the collections of the Natural History Museum, London, notably those described by Forbes (1846). Twenty species, referred to thirteen genera, are recognized. The fauna is considered to come from equivalents of a part of the lower Upper Maastrichtian *Belemnitella junior* belemnite Zone of the north-west European sequence, and the lower part of the *Abathomphalus mayaroensis* planktonic foraminiferal Zone. It represents the most diverse Upper Maastrichtian ammonite assemblage known.

EDWARD FORBES'S *Report on the Fossil Invertebrates from Southern India, collected by Mr. Kaye and Mr. Cunliffe* (1846) provided the earliest extensive account of the rich Cretaceous faunas of the subcontinent. The bulk of the material, including thirty-four named species of ammonite, are from what became known as the Valudavur beds or Group, which crop out near Pondicherry (Text-fig. 1). Forbes regarded these rocks as of early Cretaceous age, but d'Orbigny (1850) assigned them to the late Cretaceous, a view that has been generally accepted by subsequent workers. Its precise age based on the ammonites, has been taken as Campanian by many workers, although some have referred it to the Maastrichtian. Micropalaeontological work (e.g. Govidan 1972) shows the beds yielding the Pondicherry ammonites described by Forbes to be high in the Maastrichtian, regardless of how the base of that stage is defined. Increasing knowledge of Maastrichtian ammonite faunas supports this conclusion. The assemblage is of considerable importance for both historical and taxonomic reasons, for it includes the type species of ten genera or subgenera, many of which have cosmopolitan distributions. In all some thirty-two species referred to twenty-four genera or subgenera are recognized from a limited biostratigraphic interval, so that the assemblage is the most diverse Upper Maastrichtian one described to date, exceeding that of the upper part of the Miria Formation of western Australia (Henderson and McNamara 1985, plus unpublished data on heteromorphs), where twenty-six species referred to eighteen genera are known.

The history of the discovery and subsequent debate on the Pondicherry Cretaceous (Text-fig. 1) was reviewed by Blanford (1865). The earliest documented collections were made by Fontannier at an unspecified date, and by Chevalier in 1836 and 1837, who visited the area during the expedition of the French exploratory vessel *La Bonîte*, but these were not recorded until 1844. The first published report was by C. T. Kaye of the Madras Civil Service in 1840: 'The existence of a bed of fossiliferous limestone in the neighbourhood of Pondicherry has long been pretty generally known to those who take an interest in such subjects, and some attention was recently attracted to it by several communications in the *Spectator* Newspaper. An observant person, indeed, can hardly fail on being struck with the nature of the stones, which form the paving of some of the streets and steps of many of the houses in Pondicherry, and which are replete, not only with the fragments of innumerable shells, but with many ostreas and other bivalves almost as entire as if they still reposed in their proper element' (Kaye 1840, p. 37). Kaye thereafter describes a short visit, in the company of C. E. Cunliffe, to the source of these paving slabs, at Seedrapett, seven miles (11·5 km) west of Pondicherry (Text-fig. 1), where the stone yielding fossils is described as occurring in large blocks, both on the surface, and immediately below the turf. Kaye figured a baculitid (1840, pl. 1, figs 3–4)

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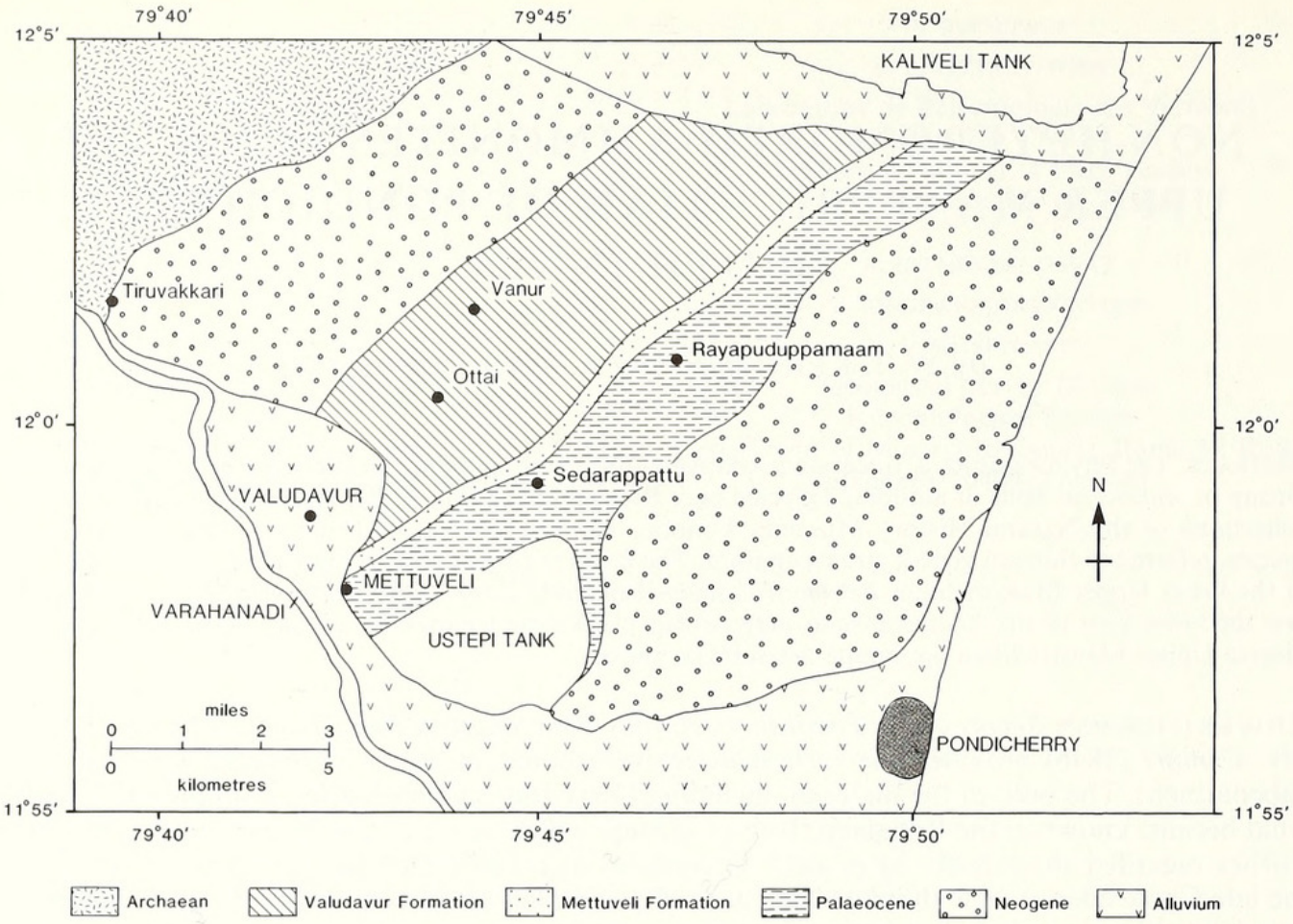


TEXT-FIG. 1. Geological sketch map of the Pondicherry district (modified after Rajagoplan 1964).

and a diplomoceratid (1840, pl. 2, fig. 11) from this locality, together with other elements of the fauna.

Kaye's paper was republished (without the plates), in the *Calcutta Journal of Natural History* (1842*a*), together with a series of additional notes and comments by Cunliffe (1842), Kaye (1842*b*), M'Clelland (1842) and Campbell (1842). More accessible is the note by Kaye (1846), where the Cretaceous rocks of Pondicherry, Verdachellum and Trichinopoly were described. Both Kaye and Cunliffe presented their collections to the Geological Society of London; the fish were subsequently described by Egerton (1845, 1846) and the invertebrates by Forbes (1846). His observations on the age of the Pondicherry Cretaceous merit full quotation, as they initiated a century of debate. Forbes (1846, p. 166) noted the remarkable Tertiary aspect of the bivalves, but concluded that rather than indicating such a date, they reflected their earliest appearance, or greatest development in eastern seas. He instead took the ammonites to be the key to the age of the fauna: 'The Pondicherry deposit may be regarded as belonging to the lowest division of the cretaceous system. In it almost all the fossils are new. Such as are analogous to known species are allied to fossils of the lower greensand of English geologists, and Neocomien of the French. In the genus most developed in this deposit, viz. *Ammonites*, three-fourths of the species belong to sections especially characteristic of the "Lower Neocomian" of the Mediterranean basin, whilst of the remainder as many representatives of oolitic fossils occur as of upper greensand species. The resemblance between many of the Pondicherry Ammonites and those of Castellane in the south of France is very remarkable' (Forbes 1846, p. 168).

D'Orbigny (1847*a*) commented on the age of material before him, as well as that described by Forbes, and concluded that it was Turonian in age (p. 507).

The specimens collected from Pondicherry by Chevalier in 1836 and 1837 were illustrated by d'Orbigny (1847*b*; the plates are, however, dated 1846) in Dumont d'Urville (1846–54), without accompanying text. A number of fragments of '*Hamites*' were illustrated, most or all of which are synonyms of Forbes's species (d'Orbigny 1850; Kennedy and Henderson in press), together with a spectacular reconstruction of a baculitid, *Baculites ornatus* d'Orbigny, 1847*b*, a synonym of *B. vagina* Forbes, 1846. Three years later, in the *Prodrome*, d'Orbigny placed the Pondicherry ammonites in his Sénonien (1850, pp. 211–216).

Kaye died, at the age of 35, in 1846 (see obituary notice in the *Quarterly Journal of the Geological Society*, **3**, 1847, p. xxvi). But collecting continued in the area, and Blanford (1865, p. 7) noted that 'in 1854, Mr. Brooke Cunliffe had, by means of his trained native collectors, obtained a large series of fossils from a hitherto unexplored locality between the original Trichinopoly and Vendechellum fossiliferous sites'. He also described the activities of a series of other collectors in the region. Blanford commenced fieldwork in the Pondicherry area in 1859, publishing his results in 1865, in an account of particular clarity (pp. 151–164). He relocated Kaye and Cunliffe's localities and recognized that the fossils occurred in 'great nodules or fragments of nodules', most of which were unfossiliferous; when fossils did occur, their numbers were vast.

Blanford was unable to obtain a single good ammonite, even though these are the most spectacular fossils in the Kaye and Cunliffe collection. 'I can only attribute my ill fortune to my having come into the field after the locality had been searched by many sharp-eyed collectors, of whose visits the rejected fragments scattered about furnish abundant evidence... In so limited an area the first come will naturally carry off the best prizes. I may notice, however, that the majority of the ammonites that I have seen from Pondicherry are evidently from the same or similar limestone nodules, and in only one or two instances have I been able to identify any as certainly from the overlying conglomerate bed' (Blanford 1865, p. 154). The last is a critical statement, for it indicates the Pondicherry fauna described below to be from a single stratigraphic interval ('a fossiliferous nodule band') and probably from a single locality or limited area near Sydrapet (Sudarampet).

Ammonites from Pondicherry were described by Stoliczka (1863–1866). In his concluding remarks (1866, p. 213), he followed Blanford in recognizing in ascending order, Ootatoor, Trichinopoly and Arrialoor groups in the Trichinopoly district, and Valudavur and Arrialoor groups in the Pondicherry district, taking the Ootatoor and Valudavur groups as one, lower division. Compared with the European succession, he believed the lower Cretaceous (Neocomian) to be absent in South India, with the lowest faunas present agreeing particularly well with the European Gault.

The possibility that the Pondicherry collections contained mixed faunas, and the need for better stratigraphic control, led Warth (1895) to re-examine the area in January and February 1894. He noted the limited outcrop (8 miles (13·2 km) long and 4 miles (6·6 km) wide) and poor exposure, but was able to subdivide the sequence, which he estimated to be some 900 feet (274 m) thick, consisting of predominantly clastic sediments with calcareous concretions:

Arrialoor group of Oldham(Horizons D–F)
Valudavur group of Oldham(Horizons A–C)

Horizon A consisted of white sands with nodules or concretions with burrows below, followed by yellow sands with gravel, and sandy clays with burrowed concretions. No body fossils were found. Horizon B included yellow and white sands with concretions and nodules, yielding body fossils, including baculitids and an ammonite. Horizon C was the source of the Kaye and Cunliffe collection, but Warth saw only concretions lying loose, or embedded in alluvium, and broke up all those he could find that were not incorporated into buildings. Horizon D was characterized as a bed of sandy shale, several feet thick, and full of casts of shells, with a few baculitids and ammonites; Warth noted that shells had been converted to phosphate, or were internal moulds in black phosphate, a preservation quite distinct from that of the Kaye and Cunliffe Collection. Horizon E was characterized by the abundance of nodules of shell limestone, generally lying loose. These

nodules had been used in building, and contained many corals, as well as a few phosphate nodules. Horizon F was characterized by calcareous nodules and burrows, a continuous limestone unit, and sands.

Warth concluded his report with a preliminary list of fossils, identified by Kossmat, in which nine ammonites are recorded from C, *Baculites vagina* and *Pachydiscus* sp. from D, and *Baculites vagina* from E. He stated that Kossmat considered the Pondicherry Cretaceous as belonging to the Ariyalur division, and that the Valudavur group of Blanford must be considered as Ariyalur only.

Kossmat's taxonomic revision of the ammonite fauna of the south India Cretaceous (1895–1898) remains the standard work on the subject. He reviewed the Pondicherry sequence (Kossmat 1897*b*), where he renamed Warth's divisions (see also Text-fig. 2):

C – Nerinea Beds = Horizon F of Warth
B – Trigonarca Beds = Horizons D and E of Warth
A – Valudavur Beds of Blanford (Anisoceras Beds) = Horizons B and C of Warth

Kossmat recognized twelve of Forbes's ammonite species as co-occurring in Warth's horizon C, and from a re-examination of Forbes's material, concluded that all came from this unit, as did most of the Pondicherry species described by Stoliczka (1863–1866). So far as we can determine, all the ammonites are from Warth's horizon C, the upper part of the Valudavur (*Anisoceras* beds) of Kossmat, and none is from the lower part, Warth's horizon B. Horizon D of Warth, the lower part of Kossmat's Trigonarca Beds, yielded *Pachydiscus gollevillensis* (Kossmat 1897*a*, pl. 6, fig. 1; 1898, p. 97 (162), pl. 15 (21), fig. 1) renamed *Pachydiscus compressus* Spath, 1922, and *Eubaculites vagina* (not illustrated). Horizon E of Warth yielded (or probably yielded) *Eubaculites vagina* (Kossmat 1897*a*, pl. 6, fig. 4), *Pseudophyllites indra* (Stoliczka 1865, pl. 58, fig. 2; Kossmat 1897*b*, p. 59), and

<table>
<tr><th>WARTH 1895</th><th>KOSSMAT 1897</th><th>RAJAGOPALAN 1965</th><th>GOVIDAN 1972</th></tr>
<tr><td>HORIZON E</td><td rowspan="2">TRIGONARCA BEDS</td><td rowspan="2">METTUVELI FORMATION</td><td rowspan="3">MAYAROENSIS SUBZONE</td></tr>
<tr><td>HORIZON D</td></tr>
<tr><td>HORIZON C</td><td rowspan="3">VALUDAYUR (ANISOCERAS) BEDS</td><td rowspan="3">VALUDAVUR FORMATION</td></tr>
<tr><td>HORIZON B</td><td>GANSSERI SUBZONE</td></tr>
<tr><td>HORIZON A</td><td>(NO MOLLUSCS)</td><td>TRICARINATA ZONE</td></tr>
</table>

TEXT-FIG. 2. Stratigraphic subdivisions of the Pondicherry Cretaceous (modified after Govidan 1972).

Brahmaites brahma. The identity of the *Baculites vagina* illustrated from horizon E is uncertain as it lacks the bituberculate flank ornament of that species, having rather feeble crescentic ribs. Kossmat (1895, pl. 19 (5), fig. 16*a–c*) figured a large baculite fragment from '1 mile NNW von Rautankupam', a locality placed, with a query, in division E of Warth. This specimen was referred to *Baculites vagina* var. *Otacodensis* Stoliczka by Kossmat, but it has a tabulate venter rather than a fastigiate one, and is *Eubaculites lyelli* (d'Orbigny 1847*b*) of authors (see Kennedy 1987*a* for synonymy) of which *carinatus* Morton (1834) is the senior synonymy.

Kossmat analysed in detail the relationship between the Cretaceous deposits of Pondicherry and those elsewhere in south India, and their age, concluding that the Valudavur (*Anisoceras*) and Trigonarca Beds were equivalent to 'the upper Senonian (Campanian, mucronata beds), and the Nerinea beds to the zone of *Nautilus danicus* (danian)' (1897*b*, p. 70).

A revised lithostratigraphy was published by Rajagoplan (1964, 1965, 1968) (Text-fig. 1), and there are additional palaeontological studies by Furon and Lemoine (1939), Sharma (1953), Rama Rao (1956, 1964), Gowda (1964) and Banerji (1968). The work of Rajagoplan (1968) and Govidan (1972) provided a micropalaeontological dating of the sequence (Text-fig. 2), which is discussed below.

THE AGE OF THE PONDICHERRY FAUNA

Kossmat (1895–1898, 1897*b*) confirmed beyond doubt the Senonian (late Cretaceous) age of the fossiliferous horizons C, D and E of Warth, and the Tertiary age of F. The precise position of the ammonite faunas has been less certain, and ages of Campanian, Campanian–Maastrichtian and Lower Maastrichtian appear in recent works. Before reviewing this question, the position of the Campanian/Maastrichtian boundary itself requires comment.

The Campanian–Maastrichtian boundary. Birkelund *et al.* (1984) listed six possible markers for the base of the Maastrichtian. As discussed elsewhere, these can be placed in relative sequence (Kennedy and Cobban in press).

Extinction of *Quadrum trifidum* (nannofossil) (youngest)
Appearance of *Pachydiscus* (*Pachydiscus*) *neubergicus* (ammonite)
Appearance of *Hoploscaphites constrictus* (ammonite)
Appearance of *Belemnella lanceolata lanceolata* (belemnite)
Extinction of *Globotruncana calcarata* (foraminiferan)
Appearance of *Globotruncana falsostuarti* (foraminiferan) (oldest)

The most widely accepted boundary for macrofossil workers is the first appearance of *B. lanceolata lanceolata* at the base of its eponymous zone, which we follow here.

There is no widely applicable ammonite zonation for the Maastrichtian; instead, belemnites provide the best macrofossil scale, although its use is limited to northern Europe and parts of the former USSR. It does, however, provide a standard for discussion (see Christensen 1975, 1979, 1988).

Upper Maastrichtian { *Belemnella casimirovensis* Zone / *Belemnitella junior* Zone
Lower Maastrichtian { *Belemnella occidentalis* Zone / *Belemnella lanceolata* Zone

We use Lower and Upper Maastrichtian in this sense here, but note that Schulz (1979) recognized a six-fold belemnite zonation for the Lower Maastrichtian.

It is important to recognize that the Campanian–Maastrichtian boundary based on planktonic foraminifera (e.g. Caron 1985) and nannofossils (e.g. Perch-Nielsen 1985) lies at a much lower level than that based on belemnites or ammonites. The top of the *Globotruncanita calcarata* foraminiferal zone and base of the *B. lanceolata* belemnite zone do not correspond, as some recent syntheses show (e.g. Marks 1984; Kent and Gradstein 1985; Bolli *et al.* 1985; Haq *et al.* 1987, 1988). There is as yet no direct correlation between the belemnite and microfossil zonations of the Maastrichtian.

For discussion purposes, we use the following Upper Campanian and Maastrichtian planktonic foraminiferal zonation, after Caron (1985):

Abathomphalus mayaroensis Zone
Gansserina gansseri Zone
Globotruncana aegyptiaca Zone
Globotruncatella havanensis Zone
Globotruncanita calcarata Zone

As already noted, planktonic foraminiferal workers commonly place the Campanian–Maastrichtian boundary at the base of the *havanensis* Zone. The base of the Maastrichtian as used here (= base of *lanceolata* belemnite zone) is much higher, probably within the *aegyptiaca* Zone.

Age of the Pondicherry fauna. Direct evidence for the age of the Pondicherry ammonite fauna comes from the planktonic foraminifera, described by Govidan (1972, table 1), who recognized a *Globotruncana tricarinata* Zone below, succeeded by a *Globotruncana gagnebini* Zone above, the latter divided into subzones of *Globotruncana gansseri* (older), and *Abathomphalus mayaroensis* (younger). From his faunal lists, Govidan's subzones correspond to the top two zones of the Maastrichtian recognized by Caron (1985) and others. The precise relationship between Warth's horizon C, the source of the ammonites revised here, and Govidan's foraminiferal zonation is not known. Horizon C probably represents the lower part of the *mayaroensis* Zone and cannot be older than *gansseri* Zone (Text-fig. 2). The occurrence of *Gansserina gansseri*, *Heterohelix* cf. *navarroensis* and *Globotruncana* sp. in the matrix of a specimen of *Glyptoxoceras rugatum* (BMNH C51125) collected by Kaye and Cunliffe, determined in thin section by Dr M. D. Brasier (Oxford University), supports this conclusion. A late Maastrichtian age may confidently be ascribed to ammonites from horizon C but the fact that Warth's horizons D and E, referred to the Mettuveli Formation by Rajagoplan (1965), also contain a Cretaceous fauna indicates that a significant time interval separates horizon C from the Cretaceous–Tertiary boundary.

Evidence from the ammonite fauna. We list below our revised nomenclature for species described by Forbes (1846), indicating the original nomenclature in parentheses, and giving known age ranges outside the Pondicherry occurrences, where known.

Phylloceras (*Neophylloceras*) *nera* (Forbes, 1846) (*Ammonites Nera* Forbes, 1846, p. 106, pl. 8, fig. 7). Known only from Pondicherry.

Phylloceras (*Neophylloceras*) *surya* (Forbes, 1846) (*Ammonites Surya* Forbes, 1846, p. 106, pl. 7, fig. 10). Restricted to the Maastrichtian, extending to the top of the *junior* Zone in Denmark (Birkelund *in press*).

Phylloceras (*Neophylloceras*) *decipiens* (Kossmat, 1897*a*). Known only from Pondicherry.

Phyllopachyceras Forbesianum (d'Orbigny, 1850) (*Ammonites Rouyanus* Forbes, 1846, p. 108, pl. 8, fig. 6). Santonian (Madagascar: Collignon 1956, 1966) to high in the *mayorensis* Zone in the Biscay region (Ward 1988).

Pseudophyllites indra (Forbes, 1846) (*Ammonites Indra* Forbes, 1846, p. 105, pl. 11, fig. 7; *Ammonites Garuda* Forbes, 1846, p. 102, pl. 7, fig. 1). Upper Santonian/Lower Campanian (*fide* Kennedy and Klinger 1977*a*) to uppermost Maastrichtian/*mayaroensis* Zone in the Biscay region of France and Spain (Ward 1988).

Saghalinites cala (Forbes, 1846) (*Ammonites Cala* Forbes, 1846, p. 104, pl. 8, fig. 4). Maastrichtian, where reliably dated, extending into the upper part of the stage (Kennedy and Klinger 1977*a*).

Anagaudryceras Valudavurense (Kossmat, 1895) (*Ammonites Juilleti* d'Orbigny; Forbes 1846 p. 101, pl. 7, fig. 2). Known only from Pondicherry.

Gaudryceras kayei (Forbes, 1846) (*Ammonites Kayei* Forbes, 1846, p. 101, pl. 8, fig. 3). Santonian/Campanian (Kennedy and Klinger 1979) to high in the Maastrichtian in Western Australia (Henderson and McNamara 1985).

Zelandites varuna (Forbes, 1846) (*Ammonites Varuna* Forbes, 1846, p. 107, pl. 8, fig. 5). Restricted to the higher parts of the Maastrichtian and extending to the top of the stage on Seymour Island (Macellari 1986; see also Zinsmeister *et al.* 1989).

Desmophyllites diphylloides (Forbes, 1846) (*Ammonites diphylloides* Forbes, 1846, p. 105, pl. 8, fig. 8). Lower Santonian (Collignon 1961) to high in the Upper Maastrichtian (Western Australia: Henderson and McNamara 1985).

Kitchinites pondicherryanus (Kossmat, 1897). Only known from Pondicherry.

Hauericeras rembda (Forbes, 1846) (*Ammonites Rembda* Forbes, 1846, p. 111, pl. 7, fig. 3; *Ammonites Durga* Forbes, 1846, p. 104, pl. 7, fig. 11). Only known from south India.

B. (*Brahmaites*) *brahma* (Forbes, 1846) (*Ammonites Brahma* Forbes, 1846, p. 100, pl. 8, fig. 1). Upper Maastrichtian, *A. mayaroensis* Zone, based on unpublished occurrences in the Biscay region.

B. (*Anabrahmaites*) *vishnu* (Forbes, 1846) (*Ammonites Vishnu* Forbes, 1846, p. 100, pl. 7, fig. 9). Upper Maastrichtian, on the basis of the occurrence in the 'Calcaires durs lithographiques à Stegasters, route de Gan à Rébenecq' (Basses-Pyrénées) (Seunes 1891, as *Puzosia haugi*; de Grossouvre 1894, as *Gaudryceras planorbiforme*), where it occurs with *Anapachydiscus fresvillensis* (Seunes, 1890*a*) and *Pachydiscus jacquoti* Seunes, 1890*a*, a species unknown earlier than the *junior* Zone in Europe (Kennedy 1986*c*) and extends into the *mayaroensis* Zone in the Biscay region (Ward 1988).

Pachydiscus (*Pachydiscus*) *neubergicus* (Hauer, 1858) (*Ammonites Chrishna* Forbes, 1846, p. 103, pl. 9, fig. 2). Lower Lower Maastrichtian (Kennedy and Summesberger 1984, 1987), lower *lanceolata* belemnite Zone in Europe to low in the Upper Maastrichtian *junior* belemnite Zone (Birkelund 1979, in press). Subspecies *dissitus* extends into the high Maastrichtian in Western Australia (Henderson and McNamara 1985). In the Biscay region it is recorded as extending to the top of the *gansseri* Zone (Ward 1988) and it may extend into the *mayaroensis* Zone (Ward and Kennedy, unpublished).

Pachydiscus (*Pachydiscus*) *egertoni* (Forbes, 1846) (*Ammonites Egertoni* Forbes, 1846, p. 108, pl. 9, fig. 1; *Ammonites ganesa* Forbes, 1846, p. 103, pl. 7, fig. 8). Known with certainty only from Pondicherry.

Pachydiscus (*Pachydiscus*) *yama* (Forbes, 1846) (*Ammonites Yama* Forbes, 1846, p. 107, pl. 7, fig. 4). Known only from Pondicherry.

Pachydiscus (*Neodesmoceras*) *soma* (Forbes, 1846) (*Ammonites Soma* Forbes, 1846, p. 102, pl. 7, fig. 7). Known only from Pondicherry.

Menuites menu (Forbes, 1846) (*Ammonites Menu* Forbes, 1846 p. 111, pl. 10, fig. 1). Known only from south India.

Sphenodiscus siva (Forbes, 1846) (*Ammonites Siva* Forbes, 1846, p. 110, pl. 7, fig. 6). Known only from Pondicherry. Similar smooth *Sphenodiscus* range through much of the Maastrichtian; in Europe, the analogue, *S. binkhorsti* (Böhm, 1898) first appears in the upper part of the *junior* Zone (Kennedy 1987, p. 178) and ranges to the top of the *casimirovensis* Zone (Machalski and Wolaszczyk 1988).

Glyptoxoceras rugatum (Forbes, 1846) (*Hamites subcompressus* Forbes, 1846, p. 116, pl. 11, fig. 6; *Hamites rugatus* Forbes, 1846, p. 117, pl. 11, fig. 2; *Hamites nereis* Forbes, 1846, p. 117, pl. 10, fig. 7). Many doubtful records are based on fragments. Sound well-dated records are Upper Maastrichtian: *junior* Zone in the Maastricht area (Kennedy 1987); high *gansseri* and low *mayaroensis* Zone in the Biscay region (Ward 1988).

Glyptoxoceras indicum (Forbes, 1846) (*Hamites indicus* Forbes, 1846, p. 116 [*pars*], *non* pl. 11, fig. 4). Maastrichtian of California (Matsumoto 1959*a*), but imprecisely positioned within the stage.

Glyptoxoceras tenuisulcatum (Forbes, 1846) (*Hamites tenuisulcatus* Forbes, 1846, p. 116, pl. 10, fig. 8; pl. 11, fig. 3). A single fragment from Denmark comes from a section that spans the Lower/Upper Maastrichtian boundary (Birkelund *in press*).

Glyptoxoceras largesulcatum (Forbes, 1846) (*Hamites large-sulcatus* Forbes, 1846 p. 117, pl. 11, fig. 1). Known only from Pondicherry.

Diplomoceras cylindraceum (Defrance, 1816). The species ranges throughout the Maastrichtian where it is well dated (Kennedy 1987; Ward 1988), and may extend into the Upper Campanian (Matsumoto and Morozumi 1980; Matsumoto 1984; Matsumoto and Miyauchi 1984).

Phylloptychoceras sipho (Forbes, 1846) (*Ptychoceras sipho* Forbes, 1846, p. 118, pl. 11, fig. 5). In the Biscay region Ward (1988) shows the species spanning upper *gansseri* and lower *mayaroensis* Zones.

'*Hamites*' *undulatus* Forbes, 1846 (p. 118, pl. 10, fig. 6). Known only from Pondicherry.

Eubaculites vagina (Forbes, 1846) (*Baculites vagina* Forbes, 1846, p. 114, pl. 10, fig. 4). Known only from south India.

Fresvillia teres (Forbes, 1846) (*Baculites teres* Forbes, 1846 p. 115, pl. 10, fig. 5). Maastrichtian of California (Matsumoto 1959*b*, p. 163), but imprecisely positioned within the stage.

Hoploscaphites indicus (Forbes, 1846) (*Ammonites*? *Indicus* Forbes, 1846, p. 114, pl. 8, fig. 9). Known only from Pondicherry.

Indoscaphites cunliffei (Forbes, 1846) (*Ammonites Cunliffei* Forbes, 1846, p. 109, pl. 8, fig. 2). In Tunisia,

Pervinquière (1907) described this species from Tebaga and Kalaat es Snam (localities discussed by him in 1903 (pp. 125–126) where it occurs in his unit 13 (1903, fig. 21), 30 m above the highest limestone beds with *Inoceramus* and *Bostrychoceras polyplocum*. Bellier *et al.* (1983) studied this interval at El Kef to the north; if the lithostratigraphic sequence is the same in the two areas, *I. cunliffei* is from the *gannseri* Zone.

Indoscaphites pavana (Forbes, 1846) (*Ammonites Pavana* Forbes, 1846, p. 110, pl. 7, fig. 5). This species occurs with *I. cunliffei* in Tunisia, and similar comments apply.

Discussion. Direct evidence indicates that the Pondicherry ammonite fauna collected by Kaye and Cunliffe comes from a limited horizon which has been variously designated: 'C' of Warth (1895); the upper part of the Valudavur beds of Blanford (1865); the *Anisoceras* beds of Kossmat, and the Valudavur Formation of Rajagoplan (1965, 1968). It probably belongs to the lower part of the *A. mayaroensis* planktonic foraminiferal Zone (Govidan 1972), which is supported by the direct evidence from thin sections described above. Indirect evidence based on comparative stratigraphic data from the Biscay region suggests a horizon either high in the *gansseri* Zone, or low in the *mayaroensis* Zone. Correlation with the belemnite sequence of northern Europe is more difficult, but a horizon somewhere in the lower Upper Maastrichtian *junior* Zone is suggested, based on the limited evidence for the last occurrence of *P.* (*P.*) *neubergicus* in Denmark. If correct, the Lower/Upper Maastrichtian boundary as used here (e.g. the *occidentalis/junior* Zone boundary) lies close to the base of the *A. mayaroensis* Zone.

As noted above, a few ammonites are known from division E of Warth (the upper part of the *Trigonarca* Beds of Kossmat) including probable *Eubaculites carinatus* (Morton, 1834). This species seems to have a long stratigraphic range. It first appears in Europe with a diverse ammonite fauna that can be indirectly correlated with the Lower Maastrichtian *sumensis* belemnite Zone of Schulz (1979), which is equivalent to the lower *occidentalis* Zone of general use. Its upper range in Europe extends into the *casimirovensis* belemnite Zone, as indicated by co-occurrence with *crassus* forms of *Hoploscaphites constrictus* (Sowerby, 1817) in southeastern France (Kennedy 1986*a*), in turn dated as *mayaroensis* Zone (Kennedy *et al.* 1986). This apparent anomaly can be explained by accepting an overlapping range for *E. vagina* and *E. carinatus*, the latter appearing before, and surviving *E. vagina*, with absence of *carinatus* from the beds with *E. vagina* in south India (although occurring above) being a local phenomenon only. An early origin for *E. carinatus* finds support not only in the Lower Maastrichtian in Europe, but also in its abundance in the Owl Creek Formation of Mississippi and Missouri in the USA (Stephenson 1955). This yields a rich nannoflora (Smith and Mancini 1982, 1983) that indicates the *Lithraphidites quadratus* nannofossil Zone, the base of which is within nannofossil zone CC25B of Perch-Neilsen (1985), known to be the age of the first occurrence of *E. carinatus* in Europe (Kennedy and Summesberger 1986).

SYSTEMATIC PALAEONTOLOGY

Respositories of specimens. The following abbreviations are used to indicate the respositories of specimens mentioned in the text: BMNH, Natural History Museum, London; GSC, Original catalogue numbers of specimens when in the Geological Society of London collections (Blake 1902); MNHP, Muséum National d'Histoire Naturelle, Paris.

Suture terminology. The system of Wedekind (1916) as reviewed by Kullman and Wiedmann (1970), is used here, with E = external lobe, L = lateral lobe, U = umbilical lobe, and I = internal lobe.

Dimensions. All dimensions are given in millimetres, with D = diameter, Wb = whorl breadth, Wh = whorl height, and U = umbilicus. Figures in parentheses refer to dimensions as a percentage of diameter.

Order AMMONOIDEA Zittel, 1884, pp. 355, 392
Suborder PHYLLOCERATINA Arkell, 1950, p. 355
Superfamily PHYLLOCERATACEAE Zittel, 1884, p. 434
Family PHYLLOCERATIDAE Zittel, 1884, p. 434
Subfamily PHYLLOCERATINAE Zittel, 1884, p. 434
Genus PHYLLOCERAS Suess, 1866, p. 76

Type species. Ammonites heterophyllus J. Sowerby, 1820, p. 119, pl. 226, by monotypy.

Subgenus NEOPHYLLOCERAS Shimizu, 1934, p. 61
[= *Paraphylloceras* Shimizu, 1935, p. 180 (*non* Salfeld, 1919); *Hyporbulites* Breistroffer, 1947; *Epiphylloceras* Collignon, 1956].

Type species. Ammonites (*Scaphites*) *ramosus* Meek, 1857, p. 45, by original designation.

Discussion. See Henderson and McNamara (1985, p. 38).

Phylloceras (*Neophylloceras*) *nera* (Forbes, 1846)

Plate 1, figs 10–12; Plate 15, figs 1–2; Text-fig. 3A

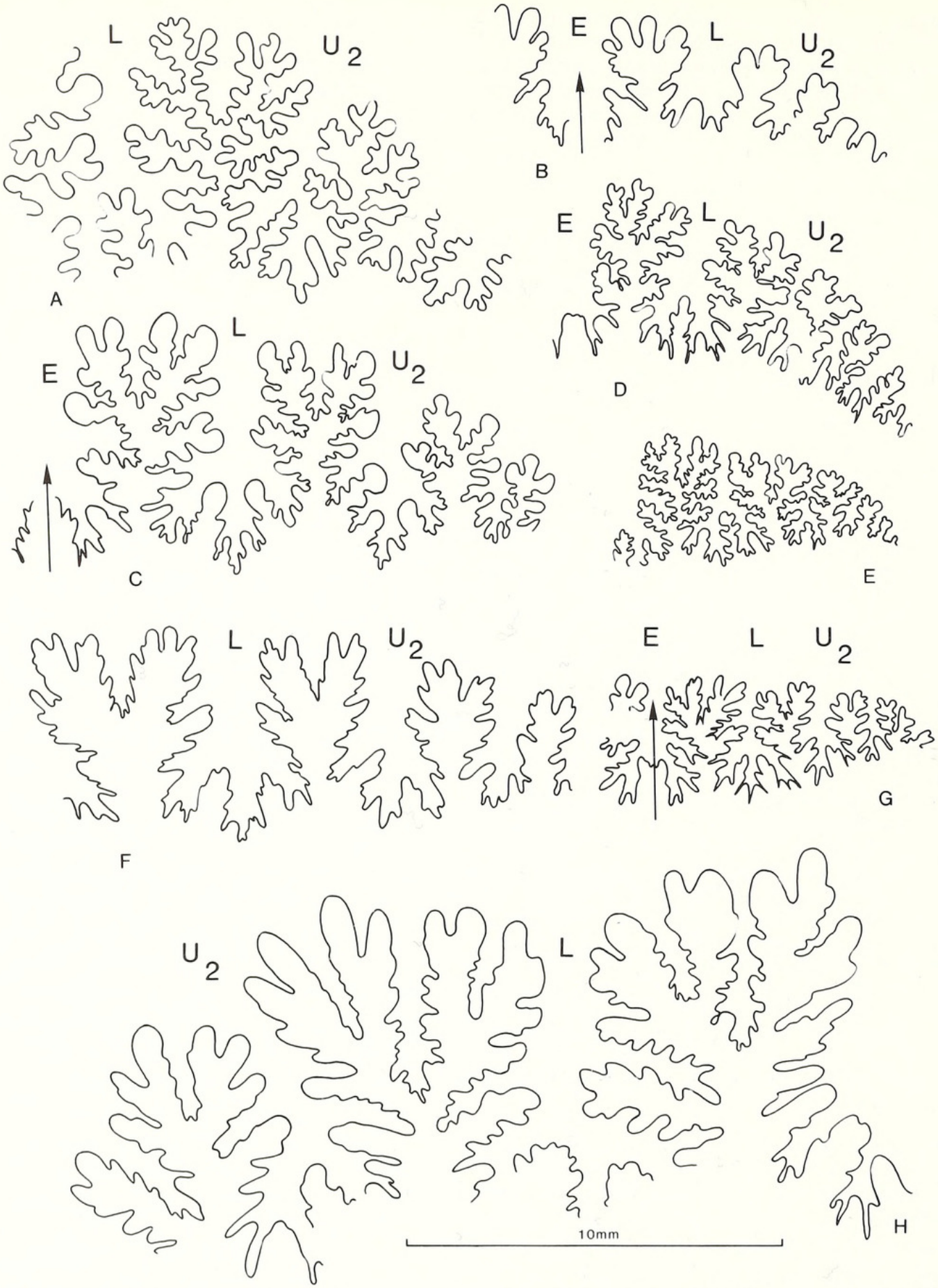
1846 *Ammonites Nera* Forbes, p. 106, pl. 8, fig. 7.
1850 *Ammonites Nera* Forbes; d'Orbigny, p. 213.
1895 *Ammonites Nera* Forbes sp.; Kossmat, p. 109 (13), pl. 16 (2), fig. 2.
non 1907 *Phylloceras nera* (Forbes); Paulcke, p. 3, pl. 14, fig. 5.
non 1921 *Phylloceras nera* (Forbes sp.) Spath, p. 40 (= *P.* (*N.*) *woodsi* Van Hoepen, 1921).
non 1926 *Phylloceras nera* (Forbes); Marshall, p. 134, pl. 19, fig. 4; pl. 26, figs 1–2; (= *P.* (*N.*) *marshalli* Shimizu, 1935).
non 1930 *Phylloceras Nera* Paulcke (*non* Forbes); Wetzel, p. 87 (= *Phylloceras* (*Hypophylloceras*) *inflatum* Stinnisbeck, 1986).

Type. Holotype, by monotypy, is BMNH C22681, the original of Forbes (1846, pl. 8, fig. 7) and Kossmat (1895 pl. 16 (2), fig. 2; GSC R10472, *ex* Kaye and Cunliffe Collection), from the Valudavur Formation, Pondicherry, south India.

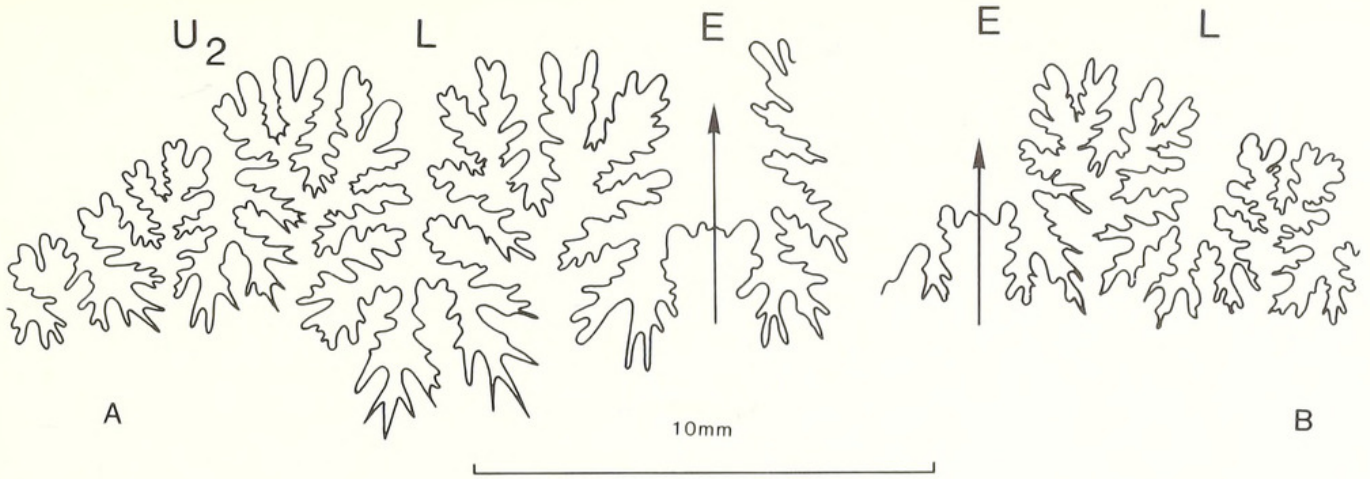
Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C22681	19·0 (100)	6·0 (31·6)	10·5 (55·3)	0·57	1·8 (9·5)

Description. The holotype is a largely septate juvenile with, perhaps, the adapical part of the body chamber preserved. Coiling is very involute, with a small umbilicus (U = 9·5%), the umbilical wall steep, passing into a narrowly rounded umbilical shoulder. The whorl section is compressed, with a whorl breadth to height ratio of 0·57, the flanks weakly convex, with maximum breadth below mid-flank, converging to a narrowly arched venter. Ornament is of evenly spaced regular lirae, separated by interspaces of similar width, numbering approximately 100 per half-whorl. They are feebly flexed; straight and rectiradiate on the inner flanks, swinging forwards on the mid-flank region but straightening and strengthening on the outer flanks, to pass near-straight across the venter. The inner flanks are, in addition, ornamented by broad undulations, four per half whorl, separated by faint, narrow grooves. Suture (Text-fig. 4A) finely divided and deeply incised from an early stage. L is trifid, and deeper than E. U has numerous auxiliary elements, which are arranged on a line that slopes backwards towards the umbilicus.

Discussion. Ribbing is asymmetric across the venter for all of the last whorl, showing the holotype to be malformed to a degree. The immaturity of the holotype, which remains the only specimen confidently assignable to the species, makes comparisons with other taxa difficult. It may be differentiated from the widely occurring *P.* (*N.*) *ramosum* (Meek, 1857) by its less flexuous, finer lirae, not projected on the venter (see Henderson 1970, p. 5, pl. 1, fig. 3; text-fig. 2 and Henderson and McNamara 1985, p. 40, pl. 1, figs 1–3; text-fig. 2), but these differences are slight, and larger collections may show the two to be synonyms. The Campanian *Phylloceras nera* of Paulcke (1907,



TEXT-FIG. 3. Sutures of A, *Phylloceras* (*Neophylloceras*) *nera* (Forbes, 1846), BMNH C22681. B, *Saghalinites cala* (Forbes, 1846), BMNH C51054. C, *Phyllopachyceras forbesianum* (d'Orbigny, 1850), BMNH C51080. D, *Gaudryceras kayei* (Forbes, 1846), BMNH C51050. E, *Gaudryceras valudavurense* (Kossmat, 1895), BMNH C51064. F, *Desmophyllites diphylloides* (Forbes, 1846), BMNH C22682. G, *Pachydiscus* (*Neodesmoceras*) *soma* (Forbes, 1846), BMNH C51039. H, *Hauericeras rembda* (Forbes, 1846), BMNH C51023.



TEXT-FIG. 4. Sutures of A, *Kitchinites pondicherryanus* (Kossmat, 1987), BMNH C47548, B, *Pachydiscus* (*Pachydiscus*) *egertoni* (Forbes, 1846), BMNH C51045.

p. 3, pl. 14, fig. 5) is probably a *P.* (*N.*) *ramosum*. Maastrichtian material from Quiriquina Island, Chile, has been described as *Phylloceras* (*Hypophylloceras*) *inflatum* Stinnisbeck, 1986 (p. 192, pl. 7, figs 7–8; text-figs 16*c*, 17*c*).

Occurrence. As for type.

Phylloceras (*Neophyllocers*) *surya* (Forbes, 1846)

Plate 1, figs 1–7, 9, 13–14; Plate 15, figs 4–5

1846 *Ammonites Surya* Forbes, p. 106, pl. 7, fig. 10.
1850 *Ammonites Surya* Forbes; d'Orbigny, p. 213.
1865 *Ammonites Surya* Forbes; Stoliczka, p. 115, pl. 58, figs 5, 5*a*, 5*b*.
1895 *Phylloceras Surya* Forbes sp.; Kossmat, p. 109 (13), pl. 16 (2), fig. 1.
1895 *Phylloceras surya* Forbes; Steinmann, p. 79, pl. 5, fig. 1.
1938 *Phylloceras* aff. *surya* (Forbes); Collignon, p. 41, pl. 7, fig. 1.
1941 *Paraphylloceras* sp. cf. *nera* (Forbes); Spath, p. 42.
1956 *Epiphylloceras mikobokense* Collignon, p. 24, pl. 2, fig. 3; pl. 4, fig. 5.
1971 *Epiphylloceras geczyi* Collignon, p. 1, pl. 640, fig. 2360.
1977*b* *Phylloceras* (*Hypophylloceras*) *mikobokense* (Collignon); Kennedy and Klinger, p. 368, pl. 12, fig. 1.
1977 *Phylloceras surya* (Forbes); Kennedy, text-figs 31.15–16.
1985 *Phylloceras* (*Neophylloceras*) *surya* (Forbes, 1846); Henderson and McNamara, p. 42, pl. 1, figs 7–8, 11–12; pl. 2, figs 1–2; text-fig. 2*g* (with full synonymy).
1986 *Phylloceras* (*Hypophylloceras*) *surya* (Forbes); Stinnisbeck, p. 193, pl. 7, figs 5–6.
1989 *Phylloceras* (*Neophylloceras*) Kennedy, text-fig. 17*k–l*.

Types. Lectotype, here designated, BMNH C51074, the original of Kossmat (1895, pl. 15 (2), fig. 1*a–c*); paralectotypes are BMNH C51075, figured by Forbes (1846, pl. 7, fig. 10*a–b*; GSC R1074), and BMNH C51076–51079 (all GSC unnumbered, *ex* Kaye and Cunliffe Collection), from the Valudavur Formation of Pondicherry, south India.

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51076	25·5 (100)	7·3 (28·6)	13·5 (52·9)	0·54	2·2 (8·6)
BMNH C51075	~ 36·5 (100)	11·0 (30·1)	20·0 (54·8)	0·55	3·5 (9·6)
BMNH C51074	~ 100·0 (100)	27·5 (27·5)	66·5 (66·5)	0·41	~ 8·5 (8·5)

Description. The shell is compressed and very involute, with U = 8·5–9·6 % of diameter, the umbilical wall low, weakly convex and subvertical, the umbilical shoulder rounded on some specimens but sharply defined on

others. The flanks are weakly convex, converging to a narrowly rounded venter; the greatest breadth is below mid-flank. There are two orders of ribs. Thin ribs separated by wide interspaces arise at the umbilical shoulder on the innermost flank, and number as few as 12 per half whorl in early growth stages, increasing to as many as 20 during later growth. They are feebly prorsiradiate, slightly convex on inner flanks and straight on the outer, declining and effacing by the ventrolateral shoulder. Fine lirae, separated by interspaces of similar width, arise on the inner flanks and follow a similar course to the ribs, but extend to, and strengthen across, the venter. They cover both ribs and interspaces, and number about 100 per half whorl. The suture is deeply incised and very finely divided, with both lobes and saddles having narrow axial zones. L is deeper than E and trifid; U has numerous auxiliary elements arranged on a line that runs straight to the umbilical shoulder.

Discussion. The largest syntype (which has suffered non-lethal injury during life) preserves the beginning of the body chamber, and may be adult. *P.* (*N.*) *surya* was discussed at length by Henderson and McNamara (1985), who indicated differences from other species.

Occurrence. Maastrichtian; south India, Madagascar, Zululand (South Africa), Western Australia, Chile, the Biscay region in France, and Denmark.

Phylloceras (*Neophylloceras*)? *decipiens* Kossmat, 1985

Plate 1, fig. 8; Plate 15, fig. 3

1846 *Ammonites varuna* Forbes [*pars*], p. 107, *non* pl. 8, fig. 5 [= *Zelandites varuna* (Forbes, 1846)].
1895 *Phylloceras decipiens* Kossmat, p. 109 (13), pl. 16 (2), fig. 3.
non 1907 *Phylloceras decipiens* Kossmat; Pervinquière, p. 55, pl. 3, figs 10–11.

Type. Holotype, by monotypy, is BMNH C51080, the original of Kossmat (1895, p. 109 (13), pl. 16 (2), fig. 3; GSC R10475, *ex* Kaye and Cunliffe Collection), a syntype of *Zelandites varuna* (Forbes, 1846), according to Kossmat. It is from the Valudavur Group of Pondicherry, south India.

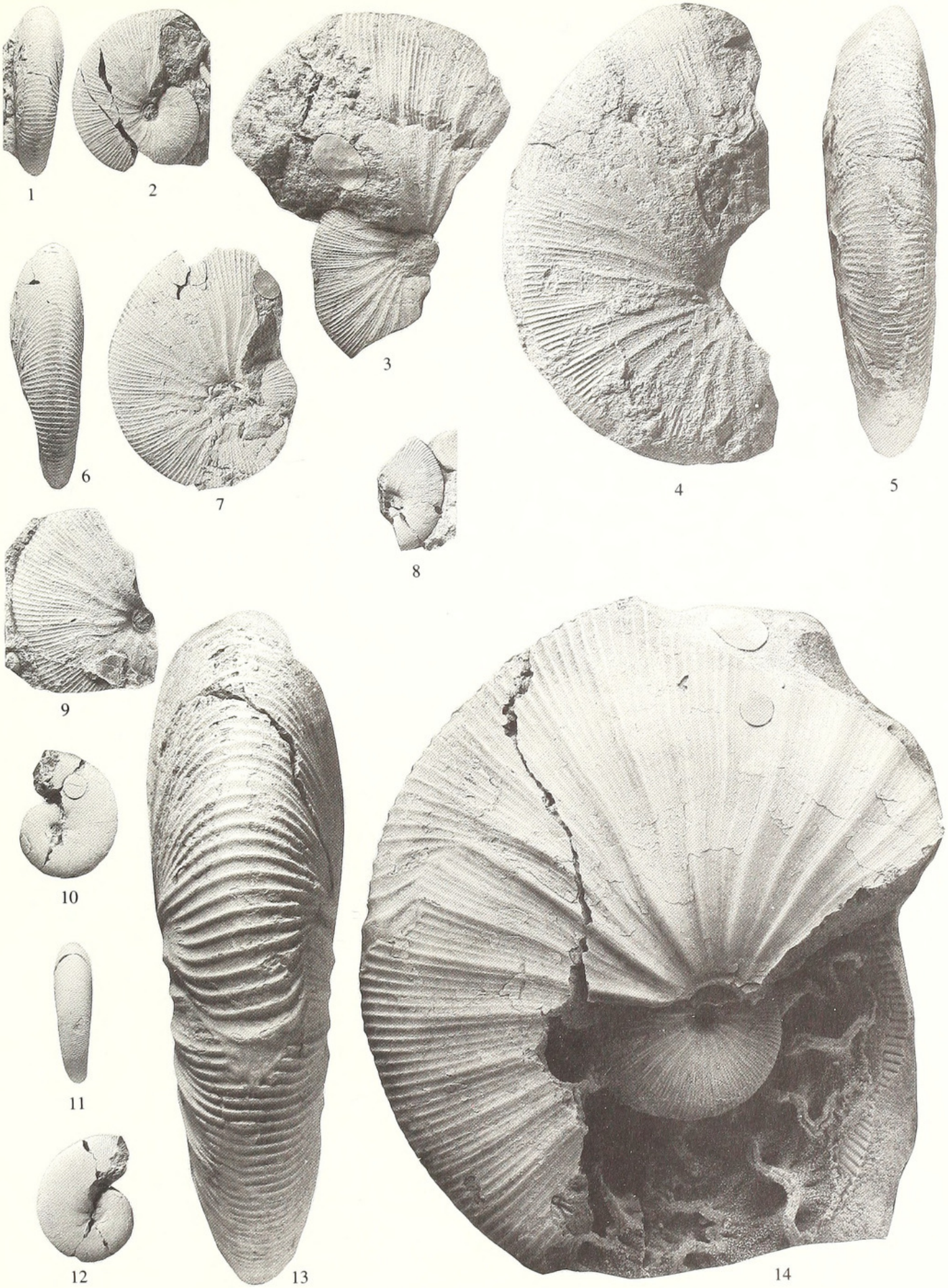
Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51080	~ 15·0 (100)	5·0 (33·3)	7·5 (50·0)	0·67	3·8 (25·3)

Description. The holotype is a partly septate juvenile, with traces of shell preserved. The whorls are depressed during the early growth stages, becoming as broad as high by a diameter of around 5 mm and thereafter increasingly compressed with a whorl breadth to height ratio of 0·67 at 15 mm diameter. The umbilicus is unusually wide for an Upper Cretaceous phylloceratid, comprising 25% of the diameter. The umbilical wall is low and convex, merging with a narrowly rounded umbilical shoulder. The flanks are weakly convex, and converge to a narrowly rounded venter; the maximum whorl breadth is below mid-flank. Fine prorsiradiate lirae, regularly spaced and separated by slightly wider interspaces on the venter, arise at the umbilical shoulder. They are straight on the inner flank, but flex back and are feebly concave on the outer; they pass straight across the venter. The last sector of body chamber shows two feeble folds on the inner flank, separated by wide interspaces. The suture lacks complexity, and is imperfectly exposed. E is broad and shallow, L deep and trifid. U is retracted.

Discussion. Shell form, ornament and suture show *decipiens* to be a phylloceratid, but its generic assignation is unclear to us. The suture is much less complex than that of *Phylloceras* (*Neophylloceras*) of equivalent size, and the umbilical diameter greater than any species referred to that subgenus; these characters readily distinguish it from other Valudavur species (Pl. 15, figs 1–5).

EXPLANATION OF PLATE 1

Figs 1–7, 9, 13–14. *Phylloceras* (*Neophylloceras*) *surya* (Forbes, 1846). 1–2, BMNH C51076, paralectotype. BMNH C51077, paralectotype. 4–5, BMNH C51075, paralectotype. 6–7 BMNH C51079, paralectotype. 9, BMNH C51078, paralectotype. 13–14, BMNH C51074, lectotype.
Fig. 8. *Phylloceras* (*Neophylloceras*?) *decipiens* Kossmat, 1895. BMNH C51080, holotype.
Figs 10–12. *Phylloceras* (*Neophylloceras*) *nera* (Forbes, 1846). BMNH C22681, holotype.
All specimens from the Valudavur Formation of Pondicherry, south India. All × 1.



KENNEDY and HENDERSON, *Phylloceras* (*Neophylloceras*)

The record of Pervinquière (1907) from the Albian of Tunisia is unlikely to be of this species.

Occurrence. As for types.

Genus PHYLLOPACHYCERAS Spath, 1927, p. 36

Type species. *Ammonites infundibulum* d'Orbigny, 1841, p. 131, pl. 39, figs 4–5, by original designation.

Discussion. Recent workers have followed Wiedmann (1964) in regarding *Phyllopachyceras* as a synonym of *Partschiceras* Fucini, 1920, or as a subgenus (e.g. Henderson and McNamara 1985). Joly (1970*a*, 1970*b*, 1976) concluded that the type species of *Partschiceras* was a *Phylloceras sensu stricto*, and we accordingly afford *Phyllopachyceras* generic status.

Phyllopachyceras forbesianum (d'Orbigny, 1850)

Plate 2, figs 1–12; Text-fig. 3c

1846 *Ammonites Rouyanus* d'Orbigny; Forbes, p. 108, pl. 8, fig. 6.
1850 *Ammonites Forbesianus* d'Orbigny, p. 213.
1865 *Ammonites Rouyanus* d'Orbigny; Stoliczka, p. 117, pl. 59, figs 5–7.
1890 *Phylloceras ezoensis* Yokoyama, p. 178, pl. 19, fig. 2*a–c*.
1895 *Phylloceras Forbesianum* d'Orbigny sp.; Kossmat, p. 109 (13), pl. 15 (1), fig. 1.
1903 *Phylloceras forbesianum* (d'Orbigny); Whiteaves, p. 328.
1921 *Phylloceras ezoense* (Yokoyama); Yabe, p. 54, pl. 8, fig. 2.
1926 *Phylloceras forbesianum* (d'Orbigny); Marshall, p. 136, pl. 19, fig. 6; pl. 27, figs 3–4.
1926 *Phylloceras minimum* Marshall, p. 137, pl. 19, fig. 8; pl. 26, figs 5–6.
1926 *Schluteria rarawa* Marshall, p. 192, pl. 19, fig. 10; pl. 32, figs 7–8.
1935 *Phyllopachyceras inflatum* Shimizu, p. 178.
1935 *Phyllopachyceras forbesianum* (d'Orbigny); Shimizu, p. 178.
1935 *Phyllopachyceras ezoense* (Yokoyama); Shimizu, p. 172.
1937 *Phyllopachyceras marshalli* Collignon, p. 26.
1941 *Phyllopachyceras forbesianum* (d'Orbigny); Spath, p. 42.
1942 *Phyllopachyceras ezoense* (Yokoyama); Matsumoto, p. 674.
1952 *Phyllopachyceras forbesianum* (d'Orbigny); Usher, p. 52, pl. 2, figs 1–5; pl. 31, figs 11–12.
1953 *Phyllopachyceras forbesianum* (d'Orbigny); Spath, p. 6, pl. 1, figs 3–5.
1956 *Phyllopachyceras forbesi* (d'Orbigny); Collignon, p. 26.
1956 *Phyllopachyceras zelandicum* Collignon, p. 31.
1962 *Phyllopachyceras forbesianum* (d'Orbigny); Wiedmann, p. 145, text-fig. 10.
1963 *Phyllopachyceras forbesianum* (d'Orbigny); Jones, p. 24, pl. 41, figs 2, 4–6, text-fig. 9.
1970 *Phyllopachyceras forbesianum* (d'Orbigny); Henderson, p. 7, pl. 1, figs 2, 4–5 (with additional synonymy).
1985 *Partschiceras* (*Phyllopachyceras*) *forbesianum* (d'Orbigny, 1850); Henderson and McNamara, p. 43, pl. 1, figs 4–6; text-fig. 3*f*.
1986 *Partschiceras forbesianum* (d'Orbigny, 1850); Kennedy and Summesberger, p. 184, pl. 1, figs 2–3, 6; pl. 15, figs 3, 6 (with additional synonymy).

Types. *Ammonites Forbesianus* d'Orbigny, 1850 (p. 213) was introduced as a new name for 'Ammonites *Rouyanus* Forbes, 1846, t. 7, p. 108, pl. 8, fig. 6'. Although only one specimen was figured by Forbes, the

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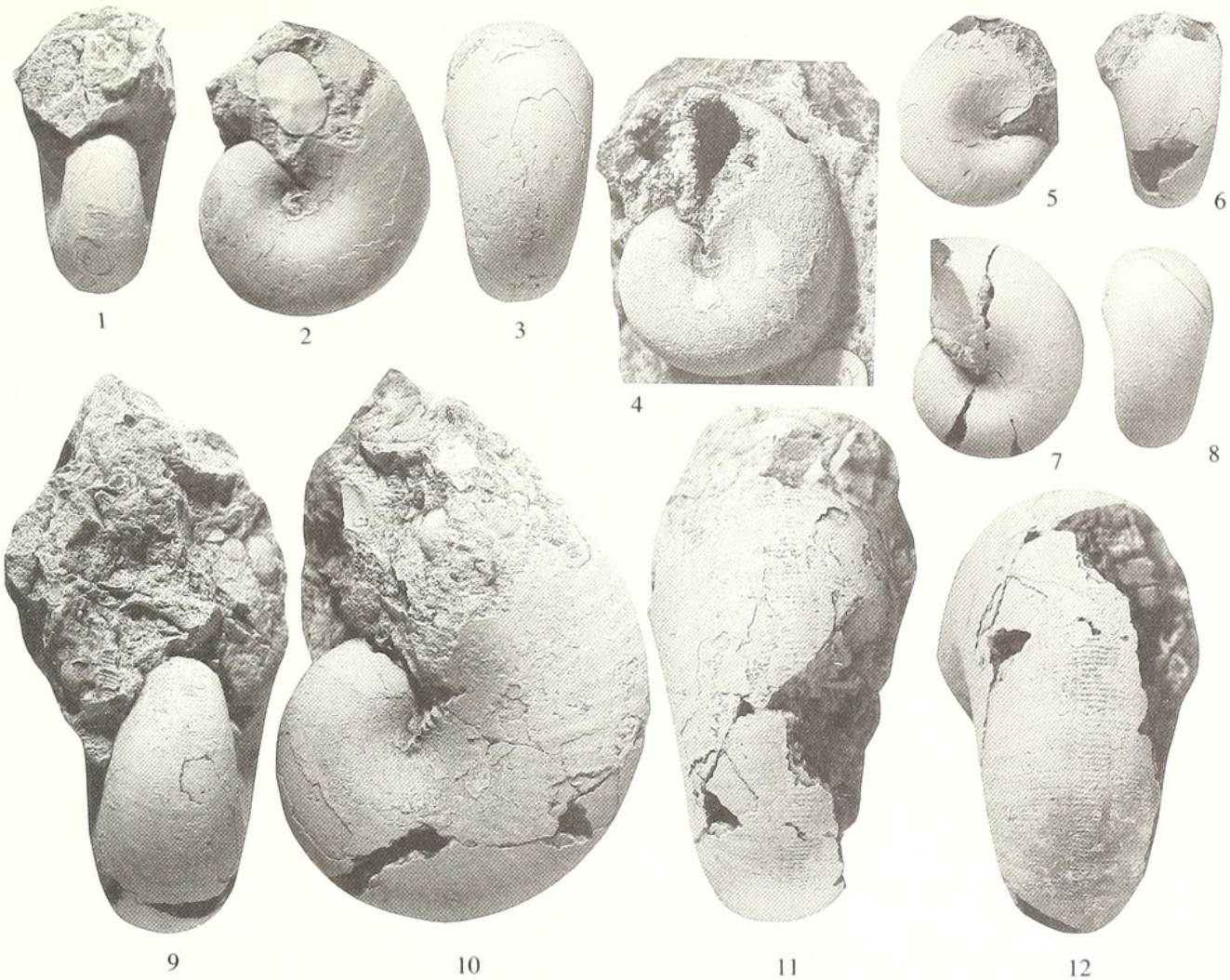
EXPLANATION OF PLATE 2

Figs 1–12. *Phyllopachyceras forbesianum* (d'Orbigny, 1850). 1–3, BMNH C51081, lectotype. 4, BMNH C51082, paralectotype. 5–6, BMNH C51083, paralectotype. 7–8, BMNH C82499, topotype (*ex*. R. Marsham Collection). 9–12, BMNH C51084, paralectotype.
Figs 13–15. *Saghalinites cala* (Forbes, 1846). BMNH C51057, paralectotype.
All specimens from the Valudavur Formation of Pondicherry, south India. All ×1.



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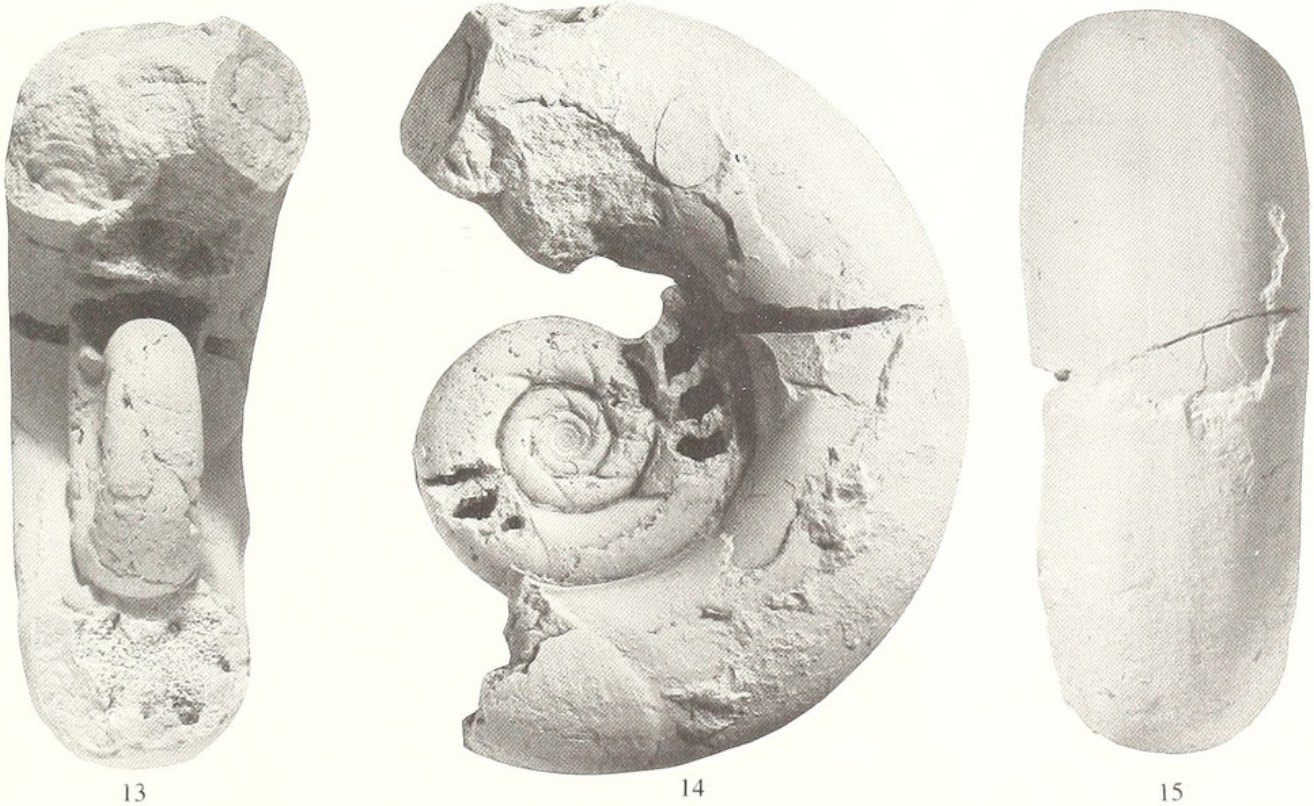


13 14 15

KENNEDY and HENDERSON, *Phyllopachyceras*, *Saghalinites*

indication in d'Orbigny is also to Forbes' description, which refers to more than one specimen so that, contrary to Phillips (1977) and others, there was a type series. We here designate BMNH C51081, the original of Forbes (1846, pl. 8, fig. 6; GSC R10476) the lectotype. Paralectotypes are BMNH 24197, C51082–51086 (GSC unregistered; all *ex* Kaye and Cunliffe Collection). All are from the Valudavur Formation of Pondicherry, south India. Topotypes are BMNH C82499 (*ex* Marsham Collection) and BMNH C3557*a–c*.

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51086	9·5 (100)	5·2 (54·7)	4·5 (47·4)	1·16	0·2 (2·1)
BMNH C51083	20·2 (100)	12·0 (59·4)	11·2 (55·4)	1·07	– (–)
BMNH C82499	24·2 (100)	~ 13·5 (55·8)	13·8 (57·0)	0·98	0·5 (2·0)
BMNH C51081	31·5 (100)	18·0 (57·1)	17·8 (56·5)	1·01	0·5 (1·6)
BMNH 24197	45·5 (100)	26·0 (57·1)	28·0 (61·5)	0·92	0·5 (1·1)

Description. Coiling is very involute, with a tiny, deep umbilicus, comprising 2% of diameter, or less. The umbilical wall is low and steep, the umbilical shoulder narrowly rounded, the flanks strongly convex, merging with the broadly rounded venter. The whorl section varies from slightly depressed to slightly compressed. Internal moulds are smooth. Where shell surface is well-preserved, the flanks are covered by dense, straight, prorsiradiate lirae that flex back on the ventrolateral shoulders to cross the venter in broad convexity. As size increases, these lirae are joined by low, distant ribs, most conspicuous on the outer flanks and venter, as in BMNH C510824, the largest paralectotype (Pl. 2, figs 9–11). A striking feature of the lectotype and largest paralectotype is the strengthening of lirae over the siphonal region, producing a coarsely ornamented ventral zone (Pl. 2, figs 11–12). Suture with tetraphylloid saddles (Text-fig. 3c).

Discussion. Henderson (1970) and Kennedy and Summesberger (1986) discussed this species and its synonyms.

Occurrence. The earliest records are from the Santonian of Madagascar (Collignon 1956, 1966) and the Lower Campanian of Spain (Wiedmann 1962). The chief occurrence of the species is in the Upper Campanian and throughout the Maastrichtian. These later records are from south India, Japan, British Columbia, Alaska, California, the sub-Antarctic Islands, Zululand (South Africa), Madagascar, Western Australia, New Zealand, north Germany, Austria, the Biscay region of France and Spain, and the former USSR.

Suborder LYTOCERATINA Hyatt, 1889, p. 7
Superfamily TETRAGONITACEAE Hyatt, 1900, p. 568
Family TETRAGONITIDAE Hyatt, 1900, p. 568
Genus PSEUDOPHYLLITES Kossmat, 1895, p. 137 (41)

Type species. Ammonites Indra Forbes, 1846, p. 105, pl. 11, fig. 7, by original designation.

Discussion. See Kennedy and Klinger (1977*a*, p. 180), Henderson and McNamara (1985, p. 49) and Kennedy (1986*a*, p. 18) for recent accounts of this genus.

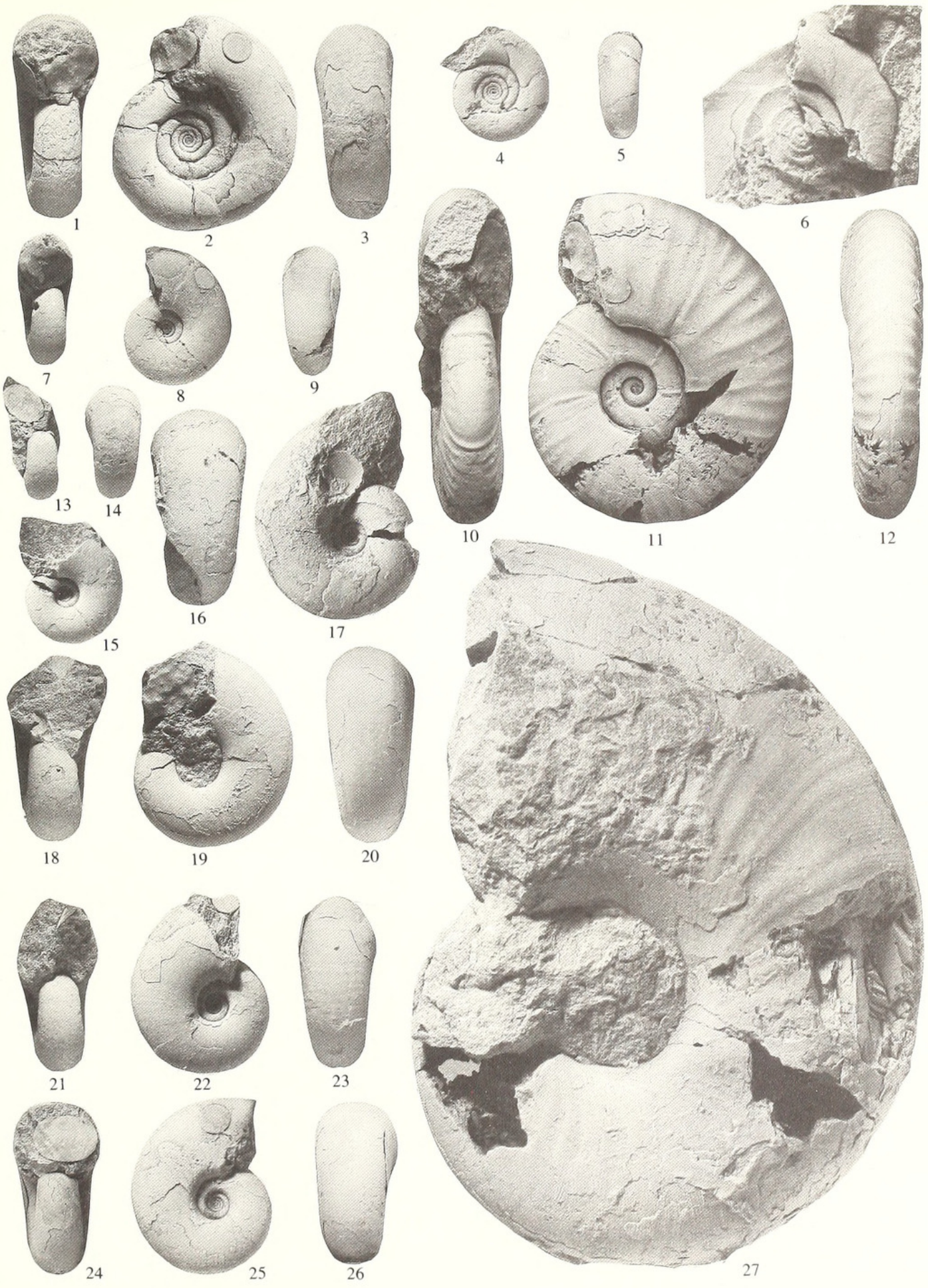
EXPLANATION OF PLATE 3

Figs 1–6. *Saghalinites cala* (Forbes, 1846). 1–3, BMNH C51057, lectotype. 4–5, BMNH C51054, paralectotype. 6, BMNH C3560, topotype.

Figs 7–9, 13–27. *Pseudophyllites indra* (Forbes, 1846). 7–9, BMNH C22676, the holotype of *Ammonites Garuda* Forbes, 1846. 13–15, BMNH C3563*a*, a topotype. 16–17, BMNH C51070, a paralectotype. 18–20, BMNH 24194*a*, a topotype (*ex* Kaye Collection). 21–23, BMNH C82491, a topotype (*ex* Marsham Collection). 24–26, BMNH C51069, a paralectotype. 27, BMNH C51068, the lectotype.

Figs 10–12. *Kitchinites pondicherryanus* (Kossmat, 1897). BMNH C47548, holotype.

All specimens from the Valudavur Formation of Pondicherry, south India. All × 1.



KENNEDY and HENDERSON, Indian Maastrichtian ammonites

Pseudophyllites indra (Forbes, 1846)

Plate 3, figs 7–9, 13–27; Plate 4, figs 1–3

1846 *Ammonites Indra* Forbes, p. 105, pl. 11, fig. 7.
1846 *Ammonites Garuda* Forbes, p. 102, pl. 7, fig. 1.
1850 *Ammonites Indra* Forbes; d'Orbigny, p. 213.
1850 *Ammonites Chrishna* Forbes; d'Orbigny [*pars*], p. 213.
1977*a* *Pseudophyllites indra* (Forbes, 1846); Kennedy and Klinger, p. 182, figs 19*a–f*, 20–22 (with full synonymy).
1985 *Pseudophyllites indra* (Forbes, 1846); Henderson and McNamara, p. 50, pl. 2, figs 7–8; pl. 3, figs 4–5; text-fig. 5*a*, 5*d*.
1986 *Pseudophyllites indra* (Forbes); Stinnisbeck, p. 199, pl. 8, fig. 4.
1986*b* *Pseudophyllites indra* (Forbes, 1846); Kennedy, p. 19, pl. 1, figs 1–5; text-figs 4*e*, 5*a*, 6*a–e* (with additional synonymy).
1986 *Pseudophyllites* cf. *indra* (Forbes, 1846); Kennedy and Summesberger, p. 187, pl. 1, figs 1, 8; pl. 3, fig. 5; text-fig. 4 (with additional synonymy).
1989 *Pseudophyllites*; Kennedy, fig. 17*b*.

Types. Lectotype, designated by Kennedy and Klinger (1977*a*, p. 182), is BMNH C51068, the original of Forbes (1846, pl. 11, fig. 7*a–b*), Kossmat (1895, pl. 16 (2), fig. 9*a–b*) and others (GSC R10468). Paralectotypes are BMNH C51069, the original of Kossmat (1985, pl. 16 (2), fig. 8; GSC R10469), and BMNH C51070–51073, GSC unregistered, all from the Valudavur Formation of Pondicherry, south India (Kaye and Cunliffe Collection). Topotypes are BMNH 24194*a–e* (Kaye Collection, 1849), BMNH C82492–82495 (Marsham Collection), and BMNH C3563*a–l*. The holotype of *Ammonites Garuda* Forbes, 1846 (p. 102, pl. 7, fig. 1) is BMNH C22676 (GSC R10462, *ex* Kaye and Cunliffe Collection), also from the Valudavur Formation of Pondicherry, south India.

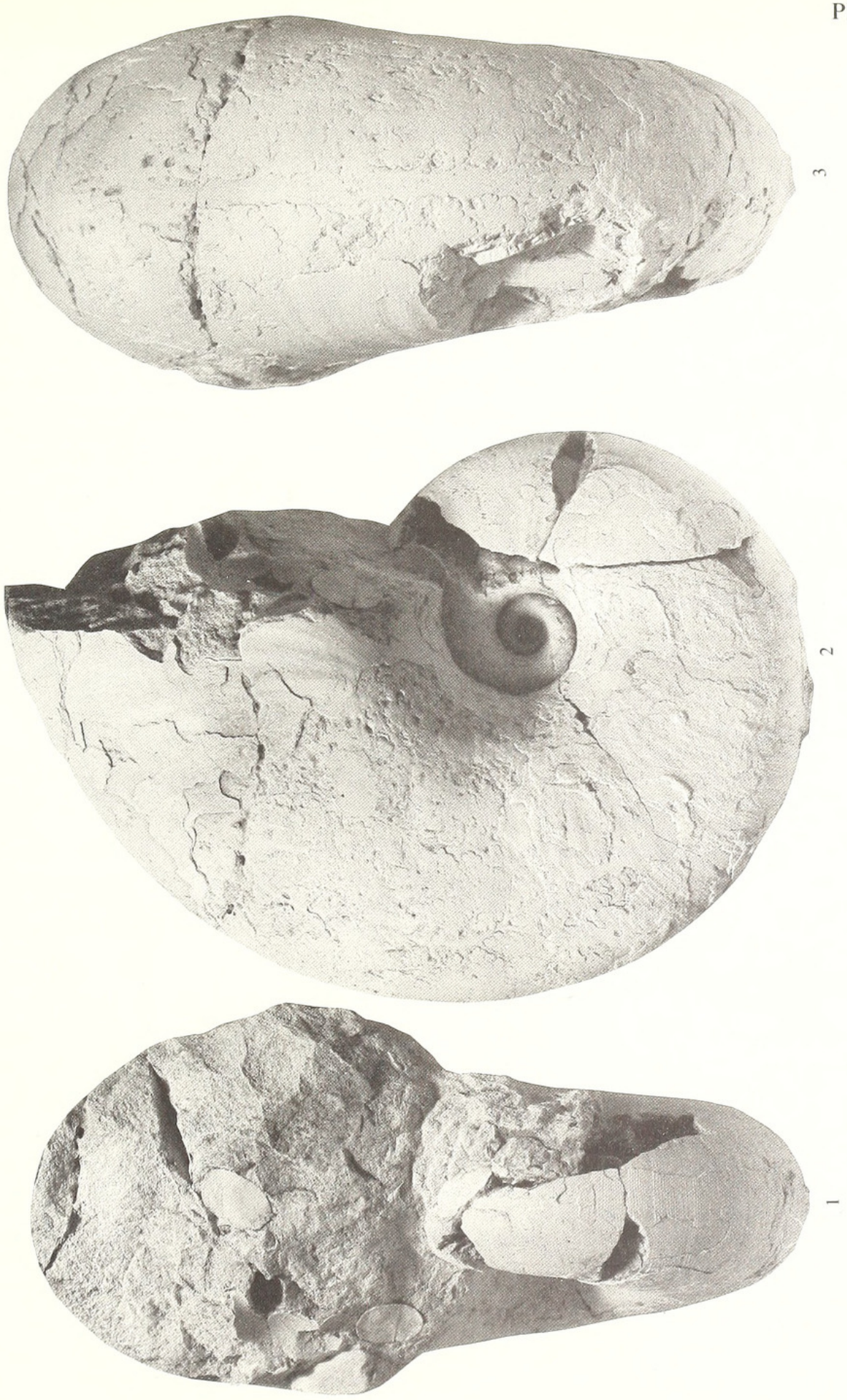
Dimensions.

	D	Wb	Wh	Wb:Wh	U
BMNH C22678	11·2 (100)	5·8 (51·8)	5·0 (44·6)	1·16	3·2 (28·6)
BMNH C35630	12·8 (100)	6·0 (46·9)	5·2 (40·6)	1·15	3·8 (29·7)
BMNH C22677	13·0 (100)	5·8 (44·6)	4·8 (36·9)	1·20	3·5 (26·9)
BMNH C3563*e*	14·0 (100)	6·5 (46·4)	5·8 (41·4)	1·12	4·0 (28·6)
BMNH C3563*a*	16·0 (100)	7·5 (46·9)	6·2 (38·8)	1·21	4·2 (26·3)
BMNH C22676	19·8 (100)	9·0 (45·5)	8·0 (40·4)	1·12	4·8 (24·2)
BMNH C82491	22·5 (100)	11·0 (48·9)	9·5 (42·2)	1·16	4·8 (21·3)
BMNH 24194*b*	23·8 (100)	10·8 (45·4)	10·0 (42·0)	1·08	5·5 (23·1)
BMNH C51049	26·8 (100)	12·5 (46·6)	11·2 (41·8)	1·1	6·0 (22·4)
BMNH C82493	29·0 (100)	13·8 (47·6)	12·2 (42·1)	1·13	6·2 (21·4)
BMNH 24194*a*	29·0 (100)	13·2 (45·5)	12·2 (42·0)	1·08	6·0 (20·7)
BMNH C51070	29·0 (100)	14·0 (48·3)	12·5 (43·1)	1·12	6·2 (21·4)
BMNH C51068	110·0 (100)	58·8 (53·5)	54·0 (49·1)	1·1	18·0 (16·4)

Description. Coiling is involute, the whorls rapidly expanding, slightly depressed in juveniles, but slightly compressed in the larger members of the type series. The umbilicus is deep with a high, feebly convex, outward-inclined umbilical wall; the umbilical shoulder is broadly rounded. The flanks are convex, converging to a broadly rounded venter, with maximum whorl breadth just outside the umbilical shoulder. Juveniles are smooth, except for growth lines and striae. These are straight and rectiradiate on the umbilical wall, swinging forwards and becoming prorsiradiate, straight on the inner flank, but feebly convex on the outer, and crossing the venter in a very shallow concavity. As size increases, delicate folds appear on the flank and venter, paralleling the growth lines. They coarsen markedly on the outer whorl of the lectotype (Pl. 3, fig. 27; Pl. 4) and the venter has a distinctive ornament of low, flat ribs and lirae and striae where the shell is preserved. Suture deeply and intricately subdivided from an early stage, with L deeper than E and asymmetrically bifid.

EXPLANATION OF PLATE 4

Figs 1–3. *Pseudophyllites indra* (Forbes, 1846). BMNH C51068, lectotype; Valudavur Formation; Pondicherry, south India, × 1.



KENNEDY and HENDERSON, *Pseudophyllites*

Discussion. The holotype of *Ammonites Garuda* Forbes, 1846 (p. 102, pl. 7, fig. 1), BMNH C22676 (Pl. 3, figs 7–9) is a juvenile of *P. indra*. The present species was discussed at length by Kennedy and Klinger (1977*a*) and Henderson and McNamara (1985), the latter having more than 70 specimens for study. Kennedy (1986*b*) and Kennedy and Summesberger (1986) clarified the affinities of the rather poorly preserved Western European material of this species. *P. indra* (and its numerous synonyms) apart, there seem to be two other well differentiated species. *P. teres* (Van Hoepen, 1920) (p. 144, pl. 25, figs 1–2) has a compressed whorl, parallel sides and a subvertical wall, is small, and transitional in certain respects to *Tetragonites* Kossmat, 1895. It is of Santonian date. *Pseudophyllites loryi* (Kilian and Reboul, 1909) and its synonyms *P. latus* (Marshall, 1926) (see revision in Henderson and McNamara 1985, p. 50, pl. 3, figs 1–3, 6–8; text-fig. 5*b–c*) and *P. skoui* Birkelund, 1965 (p. 37, pl. 3, figs 2–6; text-figs 26–33) have broader whorls that increase at a lower rate, and a spatulate ventral saddle, rather than lanceolate as in *indra*; the recess of the septal lobe is large in *indra*, but small in *loryi*.

Occurrence. Lower Campanian to Upper Maastrichtian. South India, Zululand (South Africa), Madagascar (where it is also recorded from the Upper Santonian), Western Australia, Japan, Sakhalin, Alaska, British Columbia, California, Brazil(?), Chile, The US Gulf Coast, New Jersey, Northern Ireland, Poland, Austria, and southwest France.

Genus SAGHALINITES Wright and Matsumoto, 1954, p. 110

Type species. Ammonites Cala Forbes, 1846, p. 104, pl. 8, fig. 4, by original designation.

Saghalinites cala (Forbes, 1846)

Plate 2, figs 13–15; Plate 3, figs 1–6; Text-fig. 3B

1846 *Ammonites Cala* Forbes, p. 104, pl. 8, fig. 4.
1850 *Ammonites Durga* Forbes; d'Orbigny [*pars*], p. 213.
1977*a* *Saghalinites cala* (Forbes, 1846); Kennedy and Klinger, p. 168, figs 10*a–b*, 11*a–b*, 12*d–g*, 13*a–b*, *e–k*, ?*c–d*, 14*a–f*, 15*a–f* (with full synonymy).
1977 *Saghalinites cala*; Kennedy, text-fig. 31.17.
1989 *Saghalinites*; Kennedy, text-fig. 17*b*.

Types. Lectotype, designated by Kennedy and Klinger (1977*a*, p. 169) is BMNH C51057, the original of Forbes 1846 (pl. 8, fig. 4; GSC R10466); paralectotypes are BMNH C51054, C51058 (the original of Kossmat 1895, pl. 17 (3), fig. 12, and others); BMNH C3560 is a topotype. All are from the Valudavur Formation of Pondicherry, south India.

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51054	15·8 (100)	5·8 (36·7)	4·2 (26·6)	1·38	7·2 (45·6)
BMNH C51057	32·0 (100)	13·5 (42·2)	10·8 (33·8)	1·22	14·2 (44·4)
BMNH C51058	80·0 (100)	29·5 (36·9)	23·2 (29·0)	1·27	37·5 (46·9)

Description. Coiling is very evolute, with a broad, shallow umbilicus (U = 44–47%), about 33% of the previous whorl being covered, the whorls depressed throughout. Early whorls, up to a diameter of 20 mm, have a low, convex, outward-inclined umbilical wall and a broadly rounded umbilical shoulder. On the later whorls the umbilical wall is flattened and subvertical, with the umbilical shoulder more sharply defined. The flanks are weakly convex and convergent, such that the greatest breadth is below mid-flank. The ventrolateral shoulders are broadly rounded to a diameter of about 60 mm, beyond which the venter is distinctly flattened, the ventrolateral shoulders narrowly rounded and the whorl section subquadrate. The venter is feebly concave in the largest specimen (Pl. 2, fig. 15). The mould is smooth, but for constrictions, which number about 5 per whorl. They are rectiradiate on the umbilical wall, but swing forwards and are deeply incised on the ventrolateral shoulder, are concave, flexing forwards and straight on the inner flank, flexing back and concave on the outermost flank and ventrolateral shoulder, crossing the venter in a broad shallow convexity. Growth

lines are much stronger where the shell is preserved (Pl. 3, figs 1–3, 6), and constrictions shallower, with adapical collar-ribs. BMNH C51058 is an adult body chamber, with two shallow depressions on the venter, defining low ventrolateral and siphonal ridges (Pl. 2, fig. 15). Additional faint spiral depressions, most obvious on the mould, occur on the outer flank. Suture simple (Text-fig. 3B) with E deeper than L, which is bifid. U weakly retracted on umbilical shoulder and wall.

Discussion. Differences from other species were discussed by Kennedy and Klinger (1977*a*). It most closely resembles *S. wrighti* Birkelund, 1965 (p. 30, pl. 1, fig. 5; pl. 2, figs 1–5; pl. 3, fig. 1; text-figs 14–25), originally described from West Greenland, but subsequently recorded from Denmark (Birkelund 1979), north Germany (Birkelund 1982) and Austria (Kennedy and Summesberger 1986). Topotypes are shown in Pl. 16, figs 4–6, 9–11; it differs from *S. cala* most obviously in having less flexuous constrictions.

Saghalinites n. sp. of Birkelund (1979, 1982, in press) from the Upper Maastrichtian of Kunrade, the Netherlands, and Denmark is more evolute, with much stronger constrictions.

Occurrence. Where reliably dated, this species is Maastrichtian as in south India and Zululand. There is a doubtful record from Pondoland (South Africa) that may be Santonian or Campanian, and a record from Tunisia (var. *zeugitana* Pervinquière, 1907) that is Santonian. The Antarctic specimens (Howarth 1958, p. 10, pl. 1, fig. 1) are associated with *Gunnarites antarcticus*, and here regarded as Maastrichtian.

Family GAUDRYCERATIDAE Shimizu, 1934, p. 67

Genus ANAGAUDRYCERAS Shimizu, 1934, p. 67

[= *Paragaudryceras* Shimizu, 1934, p. 67; *Murphyella* Matsumoto, 1972, p. 208]

Type species. Ammonites Sacya Forbes, 1846, p. 113, pl. 14, fig. 9, by original designation.

Anagaudryceras valudavurense (Kossmat, 1895)

Plate 5, figs 1–12; Text-fig. 3E

1846 *Ammonites Juilleti* d'Orbigny; Forbes, p. 101, pl. 7, fig. 2.
1895 *Gaudryceras Valudavurense* Kossmat, p. 163 (67), pl. 17 (3), fig. 1.

Types. Lectotype, here designated, is BMNH C51065, the original of Kossmat (1895, pl. 17 (3), fig. 1*a–b*; GSC R10460); paralectotypes are BMNH C51064, the original of Forbes (1846, pl. 7, fig. 2), and Kossmat (1895, pl. 17 (3), fig. 1*c*; GSC R10459) and BMNH C51066. All are from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51065	12·0 (100)	5·5 (45·8)	3·0 (25·6)	1·83	5·0 (41·7)
BMNH C51066	12·5 (100)	~ 6·0 (48·0)	3·2 (25·6)	1·88	5·0 (40·0)
BMNH C51064	15·0 (100)	6·5 (43·3)	5·0 (33·3)	1·3	6·0 (40·0)

Description. The types are all juveniles, the largest 15 mm in diameter. Coiling is very evolute, with rapidly expanding depressed, inflated whorls. The umbilical wall is convex, sloping outwards and passing into the flanks with no clearly demarcated umbilical shoulder. The flanks are strongly convex, the venter broadly rounded. Ornament is of dense lirae that are straight and strongly prorsiradiate on the inner flank. They break down into even finer lirae on the mid-flank region, and are prorsiradiate on the outer flank, weakly convex, and pass straight across the venter. None of the specimens shows clearly differentiated constrictions, but BMNH C51066 has broad indistinct folds on the flanks up to a shell diameter of about 8 mm. Suture finely subdivided from an early growth stage; L and E of equal depth, U retracted on inner flanks and umbilical wall (Text-fig. 3E).

Discussion. Being juvenile, the types are difficult to compare with other Maastrichtian species, and reference to *Anagaudryceras* rests mainly on the very fine ornament, which distinguishes them from

co-occurring *Gaudryceras*. *Anagaudryceras subtilineatum* (Kossmat, 1895) (see revision in Henderson and McNamara 1985, p. 45, pl. 2, figs 3–4; text-fig. 4*a*) has a lower expansion rate and distinctive polygyral shell when small, with constrictions and collar ribs. A further species known from the Maastrichtian is *Anagaudryceras politissimum* (Kossmat, 1895) (see Henderson and McNamara 1985, p. 46, pl. 1, figs 9–10; text-fig. 4*d*); it is only slightly depressed, with collar ribs and weak constrictions. Other Maastrichtian species are discussed by Birkelund (1982) and Matsumoto and Yoshida (1979).

Occurrence. As for types.

Genus GAUDRYCERAS de Grossouvre, 1894, p. 225

Type species. *Ammonites mitis* Von Hauer, 1866, p. 305, pl. 2, figs 3–4, by the subsequent designation by Boule, Lemoine and Thévenin, 1906, p. 183 (11).

Discussion. For synonymy see Kennedy and Klinger (1979, p. 128).

Gaudryceras kayei (Forbes, 1846)

Plate 5, figs 19–20, 24, 28–41; Text-fig. 3D

1846 *Ammonites Kayei* Forbes, p. 101, pl. 8, fig. 3.
1850 *Ammonites Kayei* Forbes; d'Orbigny, p. 213.
1977 *Vertebrites kayei* (Forbes); Kennedy, text-figs 31.3–31.4.
1979 *Vertebrites kayei* (Forbes); Kennedy and Klinger, p. 160, pl. 14, fig. 2; text-fig. 5 (with full synonymy).
1985 *Gaudryceras kayei* (Forbes, 1846); Henderson and McNamara, p. 46, pl. 1, figs 13–14; pl. 2, figs 5–6, 8, 10; text-fig. 4*b–c*.
1986 *Gaudryceras* (*Vertebrites*) *kayei* (Forbes); Stinnisbeck, p. 198, pl. 8, figs 2–3; text-fig. 21.
1989 *Vertebrites*; Kennedy, text-fig. 17*a*.

Types. Lectotype, by the subsequent designation of Matsumoto and Yoshida 1979 (p. 70) is BMNH C51050, the original of Forbes 1846 (pl. 8, fig. 3*a–b*; GSC R10461); paratypes are BMNH C51049, the original of Kossmat (1895, pl. 17 (3), fig. 2; GSC R10513), C41501, C51051–51053, C51055 (all Kaye and Cunliffe Collection). Topotypes are BMNH 24193*a–b* (*ex* Kaye Collection), BMNH C3448–3449, BMNH C3568 (labelled *Ammonites juilleti*), BMNH C82498 (*ex* Marsham Collection). All are from the Valudavur Formation of Pondicherry, south India.

EXPLANATION OF PLATE 5

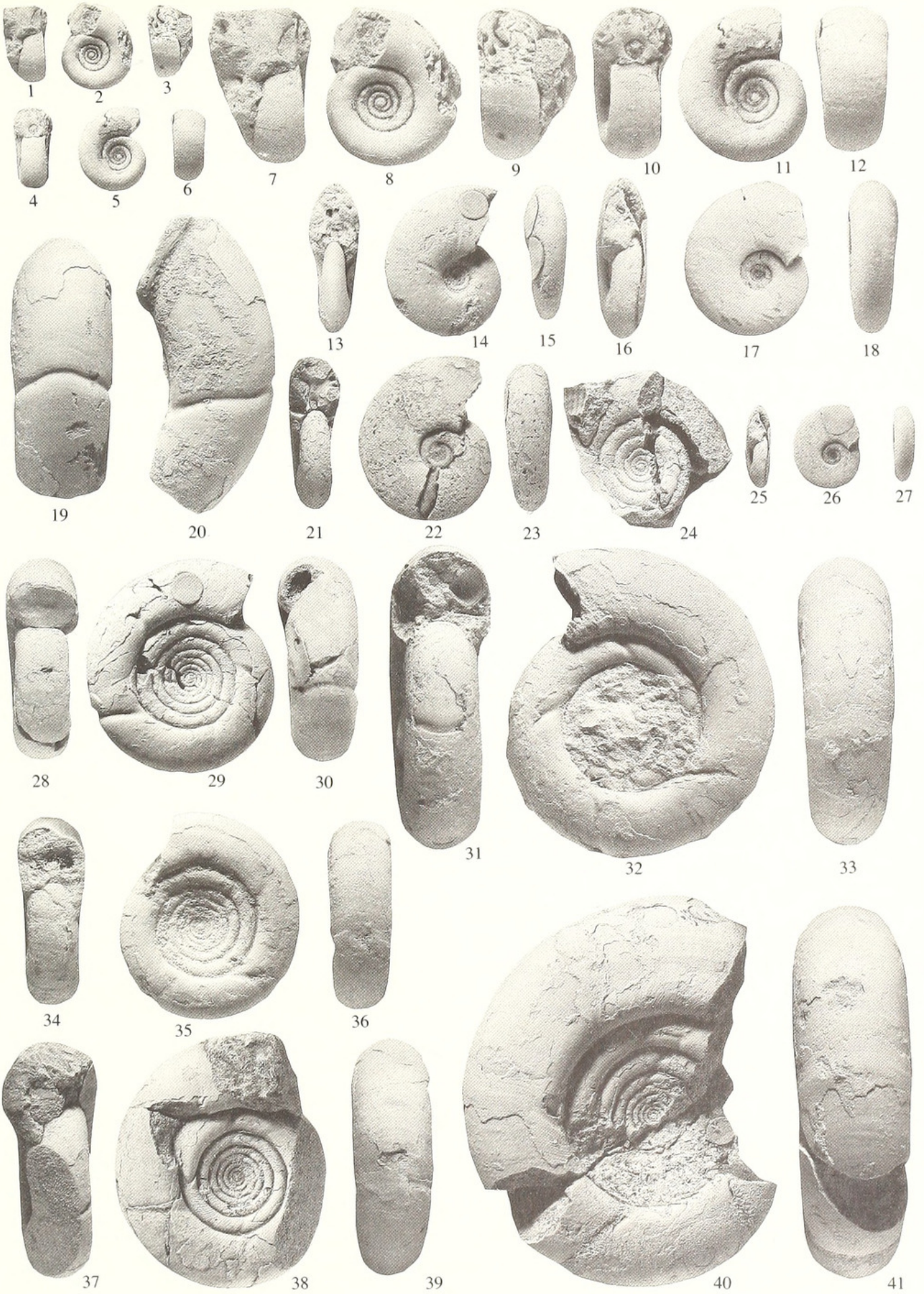
Figs 1–12. *Anagaudryceras valudavurense* (Kossmat, 1895). 1–3, 7–9, BMNH C51065, the lectotype. 4–6, 10–12, BMNH C51066, a paralectotype.

Figs 13–15. *Zelandites varuna* (Forbes, 1846). BMNH C51059, lectotype.

Figs 16–18, 21–23, 25–27. *Pachydiscus* (*Pachydiscus*) sp. juv. 16–18, 25–27, BMNH C51063, a paralectotype of *Ammonites Varuna*, the measurements of which were given by Forbes (1846, p. 107). 21–23, BMNH C51060, a further paralectotype of *Ammonites Varuna*.

Figs 19–20, 24, 28–41. *Gaudryceras kayei* (Forbes, 1846). 19–20, BMNH C41501, a paralectotype. 24, BMNH 24193*b*, a topotype (*ex* Kaye Collection). 28–30, BMNH C51050, the lectotype. 31–33, BMNH 24193*a*, a topotype (*ex* Kaye Collection). 34–36, BMNH C3558, a topotype. 37–39, BMNH C82498, a topotype. 40–41, BMNH C51049, a paralectotype.

All specimens from the Valudavur Formation of Pondicherry, south India. All × 1, except figs 7–12, 16–18, which are × 2.



KENNEDY and HENDERSON, Indian Maastrichtian ammonites

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51058	24·0 (100)	9·0 (37·5)	5·6 (23·3)	1·61	13·5 (56·3)
BMNH C3558	30·0 (100)	10·4 (34·7)	7·2 (24·0)	1·44	16·5 (55·0)
BMNH C51050	32·2 (100)	11·0 (29·3)	7·2 (22·3)	1·52	17·0 (56·7)
BMNH C82498	36·5 (100)	12·0 (32·9)	9·2 (25·2)	1·30	18·0 (49·3)
BMNH C51049	55·5 (100)	17·4 (31·4)	14·6 (26·3)	1·19	26·2 (47·2)

Description. Coiling is very evolute, with U = 47–57% of diameter, very depressed in juveniles, with a whorl breadth to height ratio of 1·61, decreasing progressively through ontogeny, to 1·19 at 55 mm diameter. Umbilical wall low, convex, inclined outwards and merging with a broadly rounded umbilical shoulder. The flanks are strongly convex, and merge into the broadly rounded venter. Where shell is preserved, narrow sharp lirae, numbering about 80 per half whorl, are separated by interspaces of variable width. They pass straight across the umbilical wall, and are markedly prorsiradiate on the inner flank, flexing backwards and feebly convex across the mid-flank, concave on the outer flank and sweeping forward on the ventrolateral shoulder to cross the venter in a broad convexity. Constrictions are prominent on internal moulds, are strong, narrow and deep, following a course parallel to the lirae and growth lines; they are irregularly spaced, and number up to five per whorl. Suture line (Text-fig. 3D) with E almost as deep as L, which is broad and trifid. There are numerous auxiliary elements on U.

Discussion. Henderson and McNamara (1985) discussed *G. kayei* in detail, and outlined differences from other species. Their material shows that the juvenile serpenticone stage is succeeded, beyond 75 mm diameter, by a less widely umbilicate one with equidimensional whorls with feebly convex flanks and a more narrowly arched venter. Their Australian specimens have four to seven constrictions per whorl in middle and later growth. *Guadryceras kayei* is intermediate in many respects between *Gaudryceras* and the paedomorphic dwarf genus *Vertebrites*, and has been referred to both.

Occurrence. This species first appears in the Santonian of Tunisia, and is also known from the Santonian–Campanian of Pondoland (South Africa), and Mexico, Santonian to Maastrichtian of south India, Campanian of Zululand (South Africa), and Maastrichtian of Western Australia, Chile, California and Madagascar.

Genus ZELANDITES Marshall, 1926, p. 147

Type species. Zelandites kaiparaensis Marshall, 1926, p. 147, pl. 20, fig. 9; pl. 31, figs 1–2.

Discussion. For synonymy see Kennedy and Klinger (1979, p. 163).

Zelandites varuna (Forbes, 1846)

Plate 5, figs 13–15; Plate 17, figs 2–3

	1846	*Ammonites Varuna* Forbes, p. 107, pl. 8, fig. 5.
non	1865	*Ammonites Varuna* Forbes; Stoliczka, p. 111, pl. 58, fig. 1 (= *Z. odiensis* (Kossmat, 1895)).
	1895	*Lytoceras* (*Gaudryceras*) *Varuna* Forbes sp., Kossmat, p. 161 (65), pl. 16 (2), fig. 4; pl. 17 (3), fig. 8.
	1895	*Lytoceras varuna* (Forbes); Steinmann, p. 84, pl. 5, fig. 2; text-fig. 7.
	1904	*Lytoceras varuna* Forbes; Wilckens, p. 187.
	1930	*Lytoceras* (*Gaudryceras*) *odiense* Kossmat; Wetzel, p. 89.
non	1938*a*	*Zelandites varuna* (Forbes) var. *japonica* Matsumoto, p. 140, pl. 14, figs 5–7; text-fig. 1*a–d*.
	1977	*Zelandites varuna* (Forbes); Kennedy, p. 296, text-fig. 31.5.
	1986	*Zelandites varuna* (Forbes); Stinnisbeck, p. 195, pl. 8, figs 5–6; text-fig. 20.
	1986	*Zelandites varuna* (Forbes, 1846); Macellari, p. 14, text-figs 11.11, 11.12, 12.
non	1989	*Zelandites*; Kennedy, text-fig. 17*c* (= *Pachydiscus* sp. juv.).

Types. Lectotype, here designated, is BMNH C51059, the original of Forbes (1846, pl. 8, fig. 5; GSC R10474); paralectotype BMNH C3567*b* also belongs here. Of other paralectotypes, BMNH C51080 (Pl. 1, fig. 8) is the

holotype of *Phylloceras* (*Hypophylloceras*) *decipiens* Kossmat, 1895; while several others (e.g. BMNH C51060 (Pl. 5, figs 21–23), C51561–51563 (Pl. 5, figs 16–18, 25–27) and C3567*c*, are juvenile pachydiscids. All are from the Valudavur Formation of Pondicherry, south India.

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51059	23·0 (100)	7·8 (33·9)	10·8 (47·0)	0·72	4·8 (20·9)

Description. The shell is compressed (Wb:Wh ratio = 0·72), with a narrow, shallow umbilicus, the umbilical wall low, and inclined outwards; the umbilical shoulder is narrowly rounded. The inner flanks are broadly rounded, the outer flanks converging to a narrowly rounded venter; the greatest whorl breadth is below mid-flank. Ornament is of growth lines on the shell, and infrequent weak constrictions, 2 to 3 per whorl, most conspicuous on the internal mould. They are rectiradiate on the umbilical wall, prorsiradiate on the inner to mid-flank, but absent on the outer flank. Suture finely subdivided; L bifid and much deeper than E. The external part of U has five bifid minor saddles, the last four following a prorsiradiate straight line.

Discussion. Both specimens referred to this species are wholly septate juveniles; only the paralectotype shows the very fine liration. As noted above, Forbes interpreted this species very widely, including both juvenile pachydiscids and a phylloceratid. *Zelandites varuna* is closely allied to the type species, *Z. kaiparaensis* Marshall, 1926 (see revision in Henderson 1970). It differs in having constrictions restricted to the inner flanks, rather than extending to the ventrolateral shoulder, while the New Zealand species has up to 12 constrictions per whorl. A large specimen from Antarctica (Macellari 1986, text-figs 11.1–11.12) has sparse constrictions, 4 per whorl, that extend out rather farther than in the types of *Z. varuna*. *Z. varuna japonica* Matsumoto, 1938*a* (p. 140, pl. 14, figs 5–7; text-fig. 1*a–d*) was differentiated from the Indian types on the basis of its more involute, more compressed shell, without constrictions in the middle growth stage. More obvious is the extension of the constrictions out to the ventrolateral shoulder (Matsumoto 1938*a*, pl. 14, fig. 5), and their greater number, in which it resembles the type species *Z. kaiparaensis*. Differences in relative proportions are less significant, as noted by Macellari (1986), who regarded *japonicum* as a synonym of *varuna*.

Occurrence. Maastrichtian, south India, Chile, and Seymour Island, Antarctica.

Order AMMONITINA Hyatt, 1889, p. 7
Superfamily DESMOCERATACEAE Zittel, 1895, p. 426
Family DESMOCERATIDAE Zittel, 1895, p. 426
Subfamily DESMOCERATINAE Zittel, 1895, p. 426
Genus DESMOPHYLLITES Spath, 1929, p. 270
[= *Schlüteria* de Grossouvre, 1894, p. 126 (*non* Fritsch in Fritsch and Kafka 1887, p. 33); *Schlütericeras* Collignon, 1938, p. 92 (*non* Hyatt, 1903, p. 110)]

Type species. Desmoceras larteti Seunes, 1891, p. 19, pl. 12 (3), fig. 2; pl. 13 (4), figs 2–3, by subsequent designation by Spath 1921 (p. 46) as type species of *Schlüteria*, of which *Desmophyllites* is replacement name.

Desmophyllites diphylloides (Forbes, 1846)

Plate 6, figs 1–9; Plate 16, figs 1–3, 7–8; Plate 17, figs 4–7; Text-fig. 3F

1846 *Ammonites diphylloides* Forbes, p. 105, pl. 8, fig. 8.
1850 *Ammonites diphylloides* Forbes; d'Orbigny, p. 213.
1865 *Ammonites diphylloides* Forbes; Stoliczka [*pars*], p. 119, pl. 59, figs 8–9 only.
1879 *Ammonites selwynianum* Whiteaves, p. 104, pl. 13, fig. 1.
1894 *Desmoceras pyrenaicum* de Grossouvre [*pars*], p. 168, pl. 37, fig. 9 only.
1898 *Desmoceras diphylloides* Forbes; Kossmat, p. 108 (173), pl. 19 (25), figs 8–9.
1898 *Desmoceras phyllimorphum* Kossmat, p. 110 (175), pl. 19 (25), fig. 10.

1907 *Puzosia* (*Latidorsella*) *diphylloides* (Forbes); Pervinquière, p. 140, pl. 6, figs 1–2, 7.
1921 *Schlüteria woodsi* Spath, p. 45, pl. 7, fig. 1.
1921 *Desmoceras simplex* Van Hoepen, p. 19, pl. 3, figs 11–16; text-fig. 10.
1921 *Desmoceras crassum* Van Hoepen, p. 20, pl. 4, figs 3, 5; text-fig. 11.
1931 *Desmoceras diphylloides* (Forbes); Basse, p. 23, pl. 2, figs 3–4.
1931 *Desmoceras* (*Latidorsella*) *diphylloides* var. *besairei* Collignon, p. 15, pl. 2, figs 8–9; pl. 2, figs 5–8.
1938 *Schlüteria larteti* (Seunes); Collignon, p. 42, pl. 7, fig. 3; text-figs K–L.
1952 *Schlüteria selwyniana* Usher, p. 63, pl. 5, figs 3–4; pl. 6, figs 1–3.
1953 *Desmophyllites diphylloides* (Forbes); Spath, p. 21, pl. 2, figs 5–6.
1955 *Desmophyllites diphylloides* (Forbes); Matsumoto and Obata, p. 121, pl. 24, figs 1–5; pl. 30, fig. 1.
1958 *Desmophyllites selwynianus* Anderson, p. 215, pl. 40, fig. 2.
1958 *Desmophyllites siskiyouensis* Anderson, p. 215, pl. 35, fig. 3; pl. 41, figs 1–3.
1958 *Desmophyllites yoloensis* Anderson, p. 216, pl. 41, fig. 6.
1959*a* *Desmophyllites diphylloides* (Forbes); Matsumoto, p. 9, pl. 3, fig. 3; text-fig. 2.
1961 *Desmophyllites diphylloides* (Forbes); Collignon, p. 61, pl. 25, figs 1–2; text-fig. 2.
1961 *Desmophyllites diphylloides* var. *besairei* Collignon; Collignon, p. 63, pl. 25, figs 4–6; text-fig. 3.
1961 *Desmophyllites diphylloides* var. *inermis* Collignon, p. 63, pl. 24, figs 4–5; pl. 25, fig. 3.
1961 *Desmophyllites diphylloides* var. *lata* Collignon, p. 64, pl. 25, figs 7–8; text-fig. 4.
1961 *Desmophyllites phyllimorphus* (Kossmat); Collignon, p. 65, pl. 26, fig. 1; text-fig. 5.
1961 *Desmophyllites larteti* (Seunes); Collignon, p. 66, pl. 26, fig. 2; text-fig. 6.
1963 *Desmophyllites phyllimorphus* (Kossmat); Jones, p. 34, pl. 10, figs 4–6.
1965 *Desmophyllites diphylloides* (Forbes); Howarth, p. 388, pl. 11, fig. 3*a–b*.
1966 *Desmophyllites diphylloides* (Forbes); Collignon, p. 84, pl. 489, fig. 1973.
1966 *Desmophyllites diphylloides* var. *besairiei* Collignon; Collignon, p. 9, pl. 458, fig. 1870.
1966 *Desmophyllites diphylloides* var. *inermis* Collignon; Collignon, p. 9, pl. 458, fig. 1871.
1966 *Desmophyllites diphylloides* var. *lata* Collignon; Collignon, p. 27, pl. 466, fig. 1900.
1971 *Desmophyllites phyllimorphus* (Kossmat); Collignon, p. 36, pl. 655, fig. 2414.
1971 *Desmophyllites diphylloides* (Forbes); Collignon, p. 37, pl. 655, fig. 2415.
1971 *Desmophyllites larteti* (Seunes); Collignon, p. 38, pl. 655, fig. 2416.
1977 *Desmophyllites diphylloides*; Kennedy, text-figs 31, 33.
1980 *Desmophyllites diphylloides* (Forbes); Blasco *et al.*, p. 483, pl. 2, figs 9–15.
1985 *Desmophyllites diphylloides* (Forbes, 1846); Henderson and McNamara, p. 54, pl. 4, figs 1–4.
1989 *Desmophyllites*; Kennedy, text-fig. 17*d*.

Types. Lectotype, by subsequent designation by Matsumoto and Obata (1955, p. 122) is BMNH C22682, the original of Forbes (1846, pl. 8, fig. 8; GSC R10470); paralectotypes are BMNH C22683 (figured by Spath 1953, pl. 2, fig. 5) and BMNH C22684–22685, all from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). BMNH C51020 is a topotype.

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C22685	9·8 (100)	4·2 (42·9)	5·0 (51·0)	0·84	1·0 (10·2)
BMNH C22684	17·8 (100)	7·8 (43·8)	9·0 (50·6)	0·87	1·8 (10·1)
BMNH C22682	20·0 (100)	8·5 (42·5)	10·0 (50·0)	0·85	2·0 (10·0)
BMNH C22683	20·5 (100)	8·5 (41·5)	10·0 (48·8)	0·85	2·0 (9·8)
BMNH C51020	39·8 (100)	17·0 (42·7)	20·5 (51·5)	0·83	~ 5·0 (12·6)

Description. The type series consists of juveniles only. The shell is slightly compressed, with whorl breadth to whorl height ratios of 0·87 in the smallest specimen and 0·83 in the largest. There is a tiny, pit-like umbilicus. The umbilical wall is subvertical, with the umbilical shoulder narrowly rounded. The flanks are weakly concave and subparallel, with the greatest whorl breadth around mid-flank; the venter is evenly rounded. The shell surface is ornamented by delicate growth lines (Pl. 6, figs 4–9; Pl. 16, figs 1–3, 7–8), prorsiradiate and straight across most of the flanks but projected forwards and concave on the outermost flank and ventrolateral shoulder and crossing the venter in a linguoid convexity. There are faint indications of constrictions, and weak collar-ribs, most prominent on the internal mould (Pl. 6, figs 1–3; Pl. 16, figs 1–2). They number up to six per whorl, are straight and prorsiradiate across most of the flank, flexing forwards and crossing the venter in a narrow linguoid convexity. Suture (Text-fig. 3F) with trifid L, equal in depth to E; U with five minor lobes on the dorsal flanks, arranged in a straight rectiradiate line.

Discussion. Henderson and McNamara (1985) described this species at length, and had over 30 specimens, septate to nearly 80 mm diameter. Their specimens show constrictions weakening markedly, with parallel flanks (Pl. 17, figs 4–7), as in the largest Indian specimen (Pl. 18, figs 5–6). The type material of *D. phyllimorphum* (Kossmat, 1898) is a compressed example of this species. This and other synonyms were discussed by Henderson and McNamara (1985). *Desmophyllites larteti* (Seunes, 1891) (p. 19, pl. 12 (3), fig. 2; pl. 13 (4), figs 2–3; see synonymy in Kennedy and Summesberger 1984, p. 156) is more compressed, with an arched venter (in part perhaps accentuated by crushing), and markedly biconcave constrictions numbering 4–5 per half whorl. The types are shown in Plate 17, figure 9 and Plate 18, figures 1–6, together with the largest Indian specimen (Pl. 17, figs 5–6) and an Australian example of *D. diphylloides* (Pl. 17, figs 4, 7) for comparison.

Occurrence. Lower Santonian to Upper Maastrichtian of south India, Western Australia, Japan, Alaska, British Columbia, California, Argentina, Angola, Pondoland and Zululand (South Africa), Tunisia and southeastern France.

Subfamily PUZOSIINAE Spath, 1922, p. 126

Discussion. For synonymy, see Wright and Kennedy (1984, p. 54).

Genus KITCHINITES Spath, 1922, p. 127

[= *Neopuzosia* Matsumoto, 1954, p. 89; ?*Oiophyllites* Spath, 1953, p. 51]

Type species. *Holcodiscus pondicherryanus* Kossmat, 1897, p. 40 (147), pl. 6 (17), fig. 6, by original designation.

Discussion. See Henderson and McNamara (1985, p. 56).

Kitchinites pondicherryanus (Kossmat, 1897)

Plate 3, figs 10–12; Text-fig. 4A

1897 *Holcodiscus pondicherryanus* Kossmat, p. 40 (147), pl. 6 (17), fig. 6.
1922 *Kitchinites pondicherryanus* (Kossmat); Spath, p. 127.
1954 *Kitchinites pondicherryanus* (Kossmat); Matsumoto, p. 89.
1957 *Kitchinites pondicherryanus* (Kossmat); Wright, p. L366, text-fig. 478.2.
1989 *Kitchinites*: Kennedy, text-fig. 18*c–d*.

Type. Holotype, by monotypy, is BMNH C47548, the original of Kossmat (1897, pl. 6 (17), fig. 6; GSC unregistered), from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C47548	52·8 (100)	14·5 (27·5)	20·0 (37·9)	0·73	16·5 (31·3)

Description. The shell is compressed, coiling moderately evolute, with U = 31·3%, and about half the previous whorl covered. The umbilical wall is low, steep and rather flattened; the umbilical shoulder is narrowly rounded. The flanks are weakly convex, and the venter narrowly rounded; the greatest breadth is below mid-flank. Broad, weak, narrow ribs, about 40 on the last whorl, arise at or just outside the umbilical shoulder or intercalate on the outer flank. They are straight and recti- to feebly prorsiradiate on the flanks, projected forward and concave on the ventrolateral shoulders, and cross the venter in a broad convexity. Occasional long ribs branch on the outer flank. There are five constrictions per whorl, each flanked by collar-ribs, of which the adapical is the stronger. The constrictions arise at the umbilical shoulder, and are straight and prorsiradiate on the flanks, generally truncating one rib. Suture with well-developed minor elements; L deeper than E, and trifid. U with bifid minor lobes, retracted (Text-fig. 4).

Discussion. The holotype is the only known specimen of the species, and consists of phragmocone plus nearly 0·4 whorls of body chamber, and is probably adult. The sparse ribbing, weakly projected on ventrolateral shoulders and venter, distinguishes this species from all others; see reviews in Henderson and McNamara (1985) and Macellari (1986).

Occurrence. As for type.

Subfamily HAUERICERATINAE Matsumoto, 1938*b*, p. 193
Genus HAUERICERAS de Grossouvre, 1894, p. 219

Type species. *Ammonites gardeni* Baily, 1855, p. 450, pl. 11, fig. 3, by original designation.

Discussion. For synonymy see Kennedy (1986*a*, p. 27).

Hauericeras rembda (Forbes, 1846)

Plate 6, figs 10–24; Pl. 17, fig. 1; Text-fig. 3H

1846 *Ammonites Rembda* Forbes, p. 111, pl. 7, fig. 3.
1846 *Ammonites Durga* Forbes, p. 104, pl. 7, fig. 11.
1850 *Ammonites Rembda* Forbes; d'Orbigny, p. 213
1850 *Ammonites Durga* Forbes; d'Orbigny [*pars*], p. 213.
1865 *Ammonites Rembda* Forbes; Stoliczka, p. 63, pl. 33, fig. 5.
1865 *Ammonites Durga* Forbes; Stoliczka [*pars*], p. 143, pl. 71, fig. 5, *non* figs 6–7 (= *Puzosia compressa* Kossmat, 1898).
non 1871 *Hauericeras rembda* Forbes; Griesbach, p. 63, pl. 3, figs 2–3 [= *H. gardeni* (Baily, 1855)].
1898 *Desmoceras* (*Hauericeras*) *Rembda* Forbes sp.; Kossmat, p. 124 (189), pl. 18 (24), fig. 9.
non 1906 *Hauericeras Rembda* Forbes; Woods, p. 333.
non 1907 *Hauericeras Rembda* Forbes; Pervinquière, p. 167, pl. 7, figs 7–10; text-fig. 69 [= *H. fayoli* (de Grossouvre, 1894)].
1955 *Hauericeras* (*Gardeniceras*) cf. *rembda* (Forbes); Matsumoto and Obata, p. 144, pl. 29, figs 6–7.
1955 *Hauericeras rembda* (Forbes); Matsumoto and Obata, p. 145, text-fig. 13.
1971 *Hauericeras rembda* (Forbes); Collignon, p. 37, pl. 655, fig. 2417.
1977 *Hauericeras rembda*; Kennedy, text-fig. 31. 18.

Types. Lectotype, by the subsequent designation of Matsumoto and Obata (1955, p. 145), is BMNH C51024, the original of Forbes (1846, pl. 7, fig. 3; GSC R10483); paralectotypes are BMNH C51023 and C51025. The figured syntype of *Ammonites durga* Forbes (1846, p. 104, pl. 7, fig. 11) is BMNH C51021, all from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). BMNH C3567 is a topotype.

EXPLANATION OF PLATE 6

Figs 1–9. *Desmophyllites diphylloides* (Forbes, 1846). 1–3, BMNH C22682, the lectotype. 4–6, BMNH C22683, a paralectotype. 7–9, BMNH C22684, a paralectotype.

Figs 10–24. *Hauericeras rembda* (Forbes, 1846). 10–12, BMNH C51024, lectotype. 13, BMNH C3567, a topotype. 14–16, BMNH C51023, paralectotype. 17, BMNH C51025, paralectotype. 18–21, BMNH C51021, a syntype of *Ammonites Durga* Forbes, 1846. 22–24, BMNH C51022, a syntype of *Ammonites Durga* Forbes, 1846.

Figs 25–26. *Brahmaites* (*Anabrahmaites*) *vishnu* (Forbes, 1846). BMNH C51026, lectotype.

All specimens are from the Valudavur Formation of Pondicherry, south India. Figs 1–20, 22–26 ×1; fig. 21 ×2.

KENNEDY and HENDERSON, Indian Maastrichtian ammonites

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51022	14·8 (100)	4·2 (28·4)	5·0 (33·8)	0·84	5·2 (35·1)
BMNH C51021	18·0 (100)	5·0 (27·8)	6·2 (34·4)	0·81	7·0 (38·9)
BMNH C51025	20·2 (100)	5·5 (27·2)	6·8 (33·7)	0·81	7·4 (36·6)
BMNH C51024	33·0 (100)	7·5 (22·7)	11·2 (33·9)	0·66	12·8 (38·8)

Description. Coiling is evolute, with U = 35–39 % of diameter, and about a third of the previous whorl covered, the umbilicus shallow with a steep, feebly convex subvertical wall and narrowly rounded umbilical shoulder. The flanks are feebly convex and subparallel, with greatest breadth around mid-flank. To a diameter of 20 mm, the venter is narrowly rounded on both shell and internal mould. From 20 mm onwards, there is a sharp keel, with a striking flattened crest with polygonal cross-section where the shell is preserved. The keel is poorly differentiated, with a rounded crest on internal moulds. Ornament is either lacking or reduced to obscure growth lines over most of the shell surface; there are traces of three or four constrictions per whorl. These are much more conspicuous on internal moulds. They are rursiradiate on the upper part of the umbilical wall, deeply incised into the flank, convex at mid-flank, concave on the outer flank, and projecting forward across the ventrolateral shoulder to form a ventral chevron. Suture (Text-fig. 3H) with E broad and much shallower than L, which is asymmetrically trifid; U retracted on the inner flanks, umbilical shoulder and wall.

Discussion. As noted by Kossmat (1898), *Ammonites durga* of Forbes represents the early growth stages of *Hauericeras rembda*, prior to development of the keel. This is well illustrated by the largest paralectotype, BMNH C51023, which shows the beginning of a keel developing at 20 mm (Pl. 6, figs 14–16). The syntypes of *durga*, BMNH C51021 and C51022 are both less than 20 mm diameter. *H. rembda* most closely resembles *Hauericeras fayoli* de Grossouvre, 1894 (p. 220 [*pars*], pl. 27, fig. 3) which is probably from Tercis, Landes, France, and probably of late Campanian age (see revisions in Kennedy and Summesberger 1984, p. 147, pl. 1, figs 8 and 12; pl. 2, figs 4, 13–15, and Kennedy 1986*b*, p. 27, text-fig. 9*a–j*). But this is much more evolute, with U = 45 %, with constrictions that are sinuous rather than biconvex. The Maastrichtian *H. sulcatum* (Kner, 1848) (p. 8, pl. 1, fig. 3; see revision in Kennedy and Summesberger 1986, p. 27, pl. 1, figs 1–7; pl. 13, fig. 2) has 6 or 7 prorsiradiate constrictions per whorl that are concave, rather than biconcave.

Occurrence. Maastrichtian of south India.

Family KOSSMATICERATIDAE Spath, 1922, p. 134
Subfamily KOSSMATICERATINAE Spath, 1922, p. 134
Genus BRAHMAITES Kossmat, 1897, p. 44 (14)
Subgenus BRAHMAITES Kossmat, 1897, p. 44 (14)

Type species. Ammonites Brahma Forbes, 1846, p. 100, pl. 8, fig. 1, by original designation.

Discussion. Two subgenera *B.* (*Brahmaites*) and *B.* (*Anabrahmaites*) are recognized, following Henderson and McNamara (1958, p. 67); see also Kennedy (1986*b*, p. 29).

Brahmaites (*Brahmaites*) *brahma* (Forbes, 1846)

Plate 7, figs 1–3; Plate 8, figs 1–11; Plate 9, figs 1–4, 8–16; Text-fig. 5

1846 *Ammonites Brahma* Forbes, p. 100, pl. 8, fig. 1.
1865 *Ammonites Brahma* Forbes; Stoliczka, p. 163, pl. 79, figs 2–4.
1894 *Hauericeras fayoli* de Grossouvre [*pars*], p. 220, *non* pl. 27, fig. 3.

EXPLANATION OF PLATE 7

Figs 1–3. *Brahmaites* (*Brahmaites*) *brahma* (Forbes, 1846). BMNH C51029, the lectotype; Valudavur Formation; Pondicherry, south India, × 1.

KENNEDY and HENDERSON, *Brahmaites* (*Brahmaites*)

1897 *Brahmaites Brahma* Forbes sp.; Kossmat [*pars*], p. 45 (152), *non* pl. 8 (19), figs 7–8 [= *Brahmaites* spp.].
1901 *Hauericeras fayoli* de Grossouvre; de Grossouvre, p. 382.
?1907 *Brahmaites Brahma* Forbes; Boule *et al.*, p. 7 (27).
1925 *Brahmaites Brahma* Forbes; Diener [*pars*], p. 103.
non 1938 *Brahmaites Brahma* Forbes; Collignon, p. 97 (44), pl. 8, figs 1–2.
1938 *Brahmaites brahma* Forbes; Roman, p. 390, pl. 40, fig. 377.
1957 *Brahmaites brahma* (Forbes); Wright, p. L376, text-fig. 491.1.
non 1971 *Brahmaites brahma* Forbes; Collignon, p. 20, pl. 647, figs 2396–2397.
1977 *Brahmaites brahma*; Kennedy, text-fig. 31.20–21.
1985 *Brahmaites brahma* (Forbes, 1846); Henderson and McNamara, p. 70.
1986*b* *Brahmaites brahma* (Forbes, 1846); Kennedy, p. 29, text-fig. 10*a–k*.
1989 *Brahmaites*; Kennedy, text-fig. 17*f*.

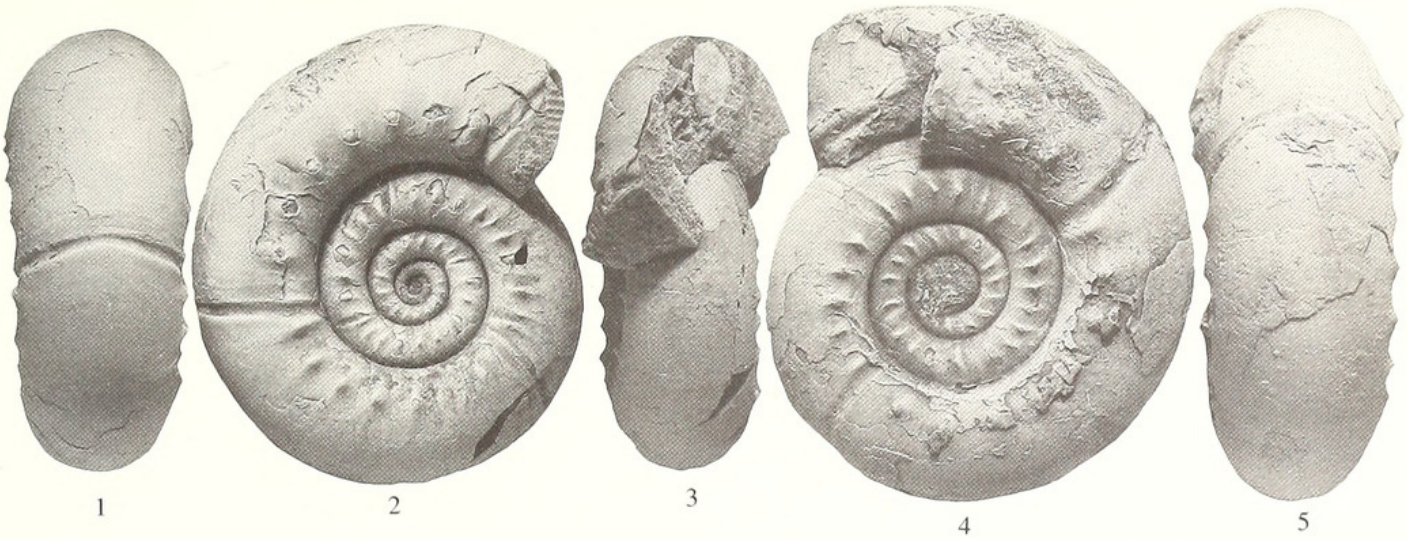
Types. Lectotype, by the subsequent designation of Kennedy 1986*b* (p. 29) is BMNH C51029, the original of Forbes (1846, pl. 8, fig. 1*a–b*; GSC R10457); paralectotypes are BMNH C51030, the original of Forbes (1846, pl. 8, fig. 1*c*; GSC R10458), BMNH C51031–51037, all from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH 24195*a*	15·2 (100)	8·5 (55·9)	4·4 (28·9)	1·93	5·6 (36·8)
BMNH C3564*a*	15·5 (100)	8·5 (54·8)	4·5 (29·0)	1·90	5·8 (37·4)
BMNH C3564*b*	16·2 (100)	8·7 (53·7)	4·4 (27·1)	1·98	6·0 (37·0)
BMNH C51034	17·5 (100)	9·8 (56·0)	5·0 (28·6)	1·96	6·2 (35·4)
BMNH C82496	18·0 (100)	9·8 (54·4)	4·8 (26·7)	2·04	6·2 (34·4)
BMNH C51036	18·2 (100)	9·5 (52·2)	5·2 (28·6)	1·82	6·2 (34·1)
BMNH C51037	18·5 (100)	9·8 (53·0)	5·8 (31·3)	1·69	6·2 (33·5)
BMNH 24195*b*	23·5 (100)	11·0 (46·8)	6·0 (25·5)	1·83	9·0 (38·3)
BMNH C51033	25·2 (100)	12·2 (48·4)	7·2 (28·6)	1·69	9·0 (35·7)
BMNH 24195*c*	45·5 (100)	19·5 (42·9)	12·0 (26·4)	1·62	20·2 (44·4)
BMNH C51032	49·0 (100)	20·5 (41·8)	13·2 (26·9)	1·50	22·2 (45·3)
BMNH C51035	63·5 (100)	27·4 (43·1)	18·0 (28·3)	1·52	29·5 (46·5)
BMNH C51029	108·0 (100)	35·0 (32·4)	29·0 (26·9)	1·21	56·0 (51·8)

Description. Coiling is very evolute, serpenticone, with a broad umbilicus, U = as little as 33% in juveniles but increasing to 51·8% in adults. The umbilical wall is convex, sloping outwards and merging with a rounded umbilical shoulder. The flanks are low and convex, the venter broadly arched. The greatest whorl breadth is just outside the umbilical shoulder with a whorl breadth to height ratio of up to 2 in juveniles, decreasing to as little as 1·21 in adults. Umbilical bullae are already present at less than 10 mm diameter (Pl. 9, fig. 4), and number 16–22 per whorl. They disappear at a diameter of about 80 mm. The bullae are borne on prorsiradiate ribs that arise high on the umbilical wall and are distant, straight and prorsiradiate, and limited to the flanks at diameters of 60 mm and less. At larger diameters, including those where bullae have been lost, the ribs extend across the ventrolateral shoulder (where they are markedly convex), weakening over the venter, which they cross in a broad convexity; shorter intercalated ribs may also appear. Prominent constrictions, 3 to 4 per whorl, are much more prorsiradiate than the ribs, are deeply incised into the umbilical shoulder, straight on the flanks, projected forward over the ventrolateral shoulder, and cross the venter in a broad convexity (Pl. 7; Pl. 8, figs 1, 9, 11). They are preceded by a strong collar, often raised into a bulla on the umbilical shoulder, and bearing a siphonal bulla at diameters in excess of 90 mm. The suture (Text-fig. 5) is only moderately incised; L is trifid and deeper than E. U has trifid minor lobes, and is retracted on the umbilical wall.

EXPLANATION OF PLATE 8

Figs 1–11. *Brahmaites* (*Brahmaites*) *brahma* (Forbes, 1846). 1–3, BMNH 24195*a*, a topotype (*ex* Kaye Collection). 4–5, BMNH C51032, a paralectotype. 6–8, BMNH C51031, a paralectotype. 9–11, BMNH C51035, a paralectotype.
All specimens from the Valudavur Formation of Pondicherry, south India. All × 1.



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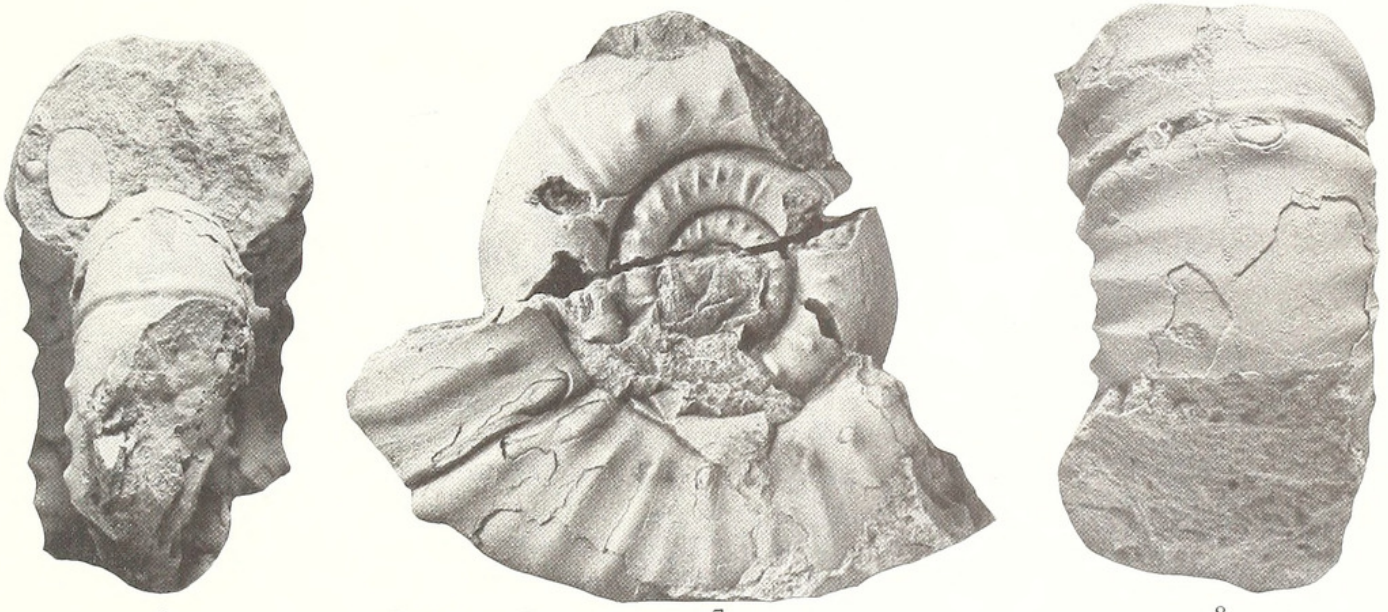

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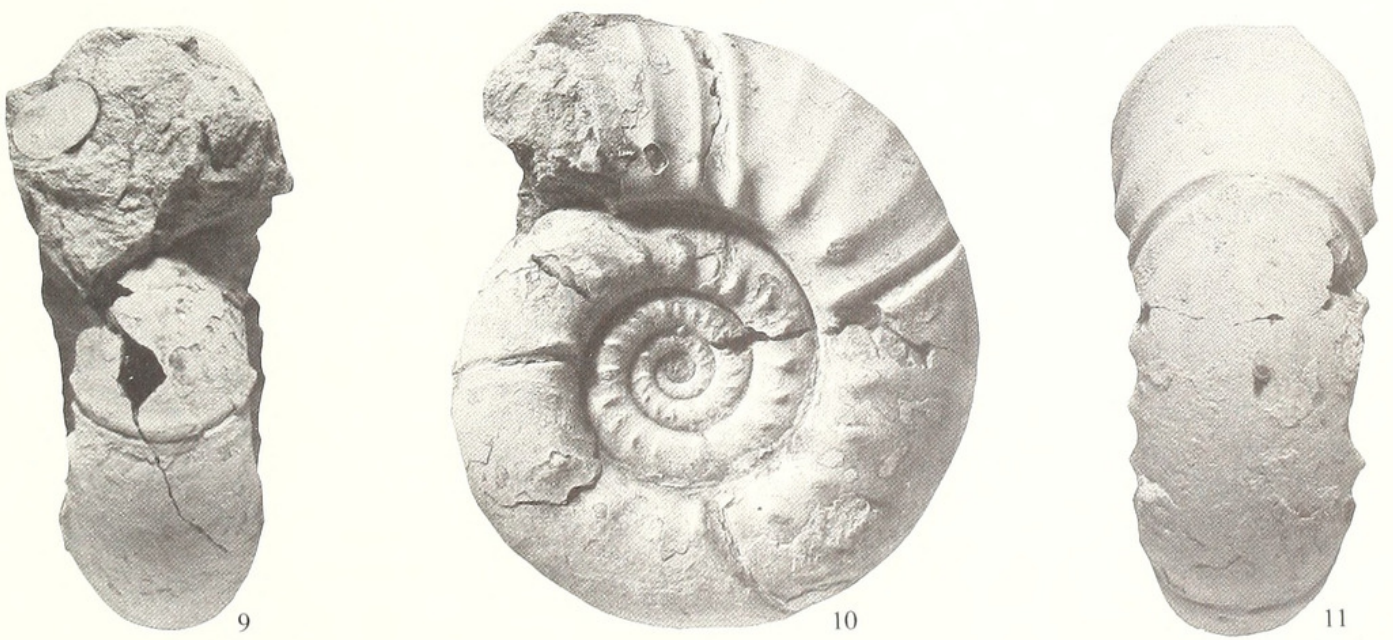

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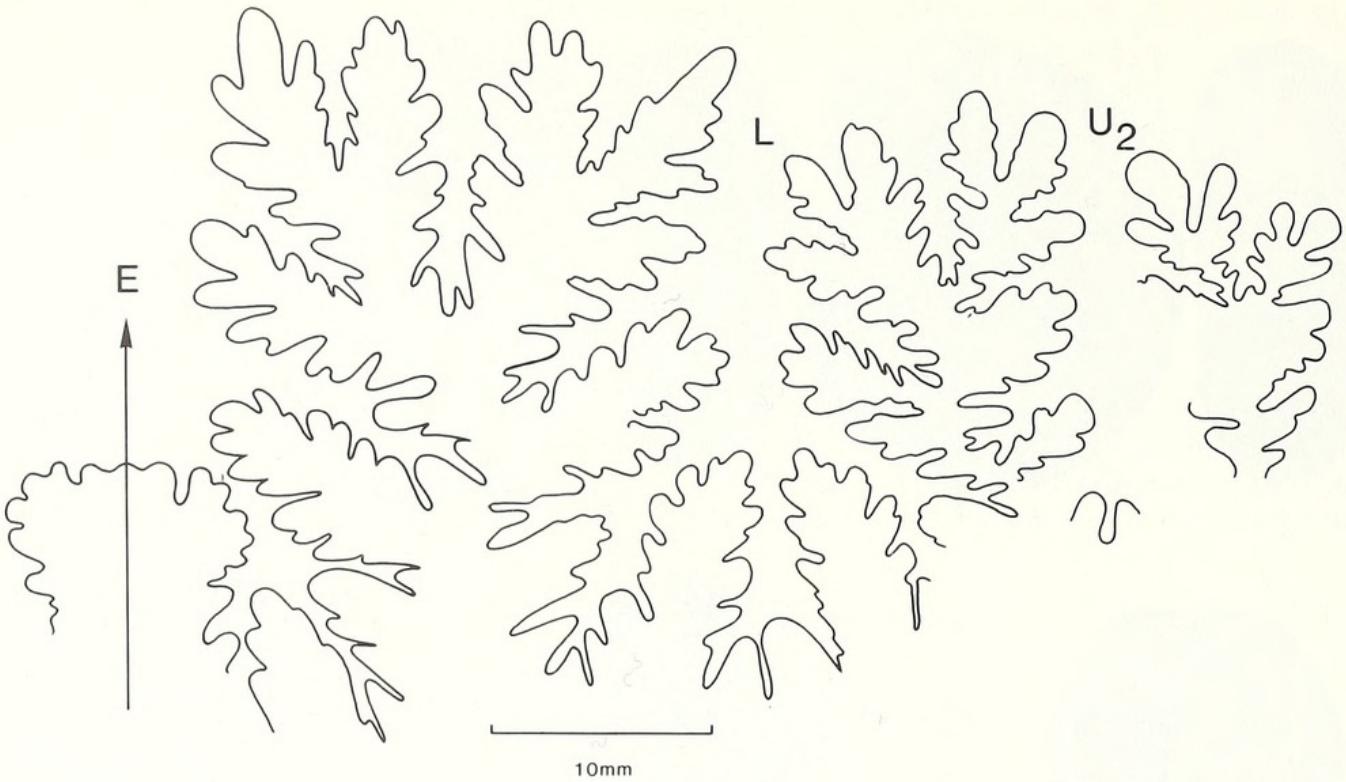
KENNEDY and HENDERSON, *Brahmaites* (*Brahmaites*)



TEXT-FIG. 5. Suture of *Brahmaites* (*Brahmaites*) *brahma* (Forbes, 1846), BMNH C10535.

Discussion. The large suite of specimens available shows the whole of the ontogeny of this species, the lectotype being an adult, with about a whorl of body chamber, and a terminal constriction (Pl. 7). *B.* (*B.*) *kossmati* Henderson and McNamara, 1985 (p. 68, pl. 6, figs 11–14; pl. 7, fig. 1; text-figs 9–10) is more widely umbilicate and has a more depressed whorl than *B.* (*B.*) *brahma*, and stronger and more numerous ribs when adult.

Specimens described by Kossmat (1897) as *Brahmaites brahma* and from the Arialur stage of Trichinopoly belong to other forms; his plate 8 (19), figure 7 is closer to *B.* (*B.*) *kossmati* Henderson and McNamara, 1985, but does not develop the distinctive mature ribbing of that species. Kossmat's smaller specimen (pl. 8 (19), fig. 8) has delicate ribs arising in groups from umbilical bullae, quite unlike the present species. *B.* (*B.*) *brahma* of Collignon (1938, 1971) from Madagascar have whorl breadth to height ratios of about 1·2 at shell diameters of 50–80 mm, much less than in the type series, suggesting they represent some local form, although Stoliczka (1865) described an equally slender form from Pondicherry.

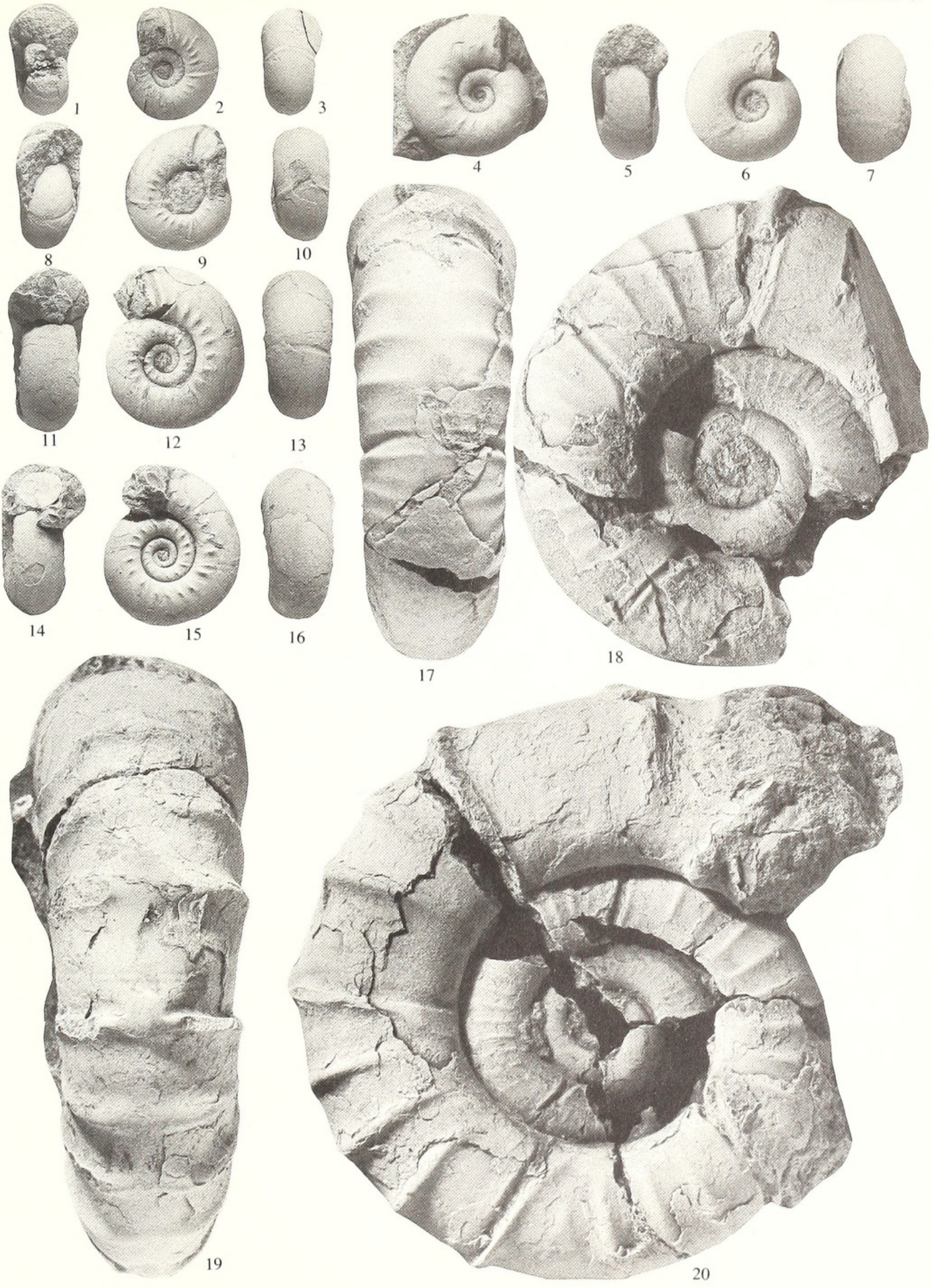
Occurrence. Maastrichtian of south India and south-western France.

EXPLANATION OF PLATE 9

Figs 1–4, 8–16. *Brahmaites* (*Brahmaites*) *brahma* (Forbes, 1846). 1–3, BMNH C82496, a topotype. 4, BMNH C51036, a paralectotype. 8–10, BMNH C51036, a paralectotype. 11–13, BMNH C51033, a paralectotype. 14–16, BMNH 24195*b*, a topotype.

Figs 5–7, 17–20. *Brahmaites* (*Anabrahmaites*) *vishnu* (Forbes, 1846). 5–7, BMNH C51028, found with the syntypes of *Ammonites Garuda* Forbes, 1846. 17–18, BMNH 24192, a topotype (*ex* Kaye Collection). 19–20, BMNH 83624*a*, a topotype (*ex* Marsham Collection).

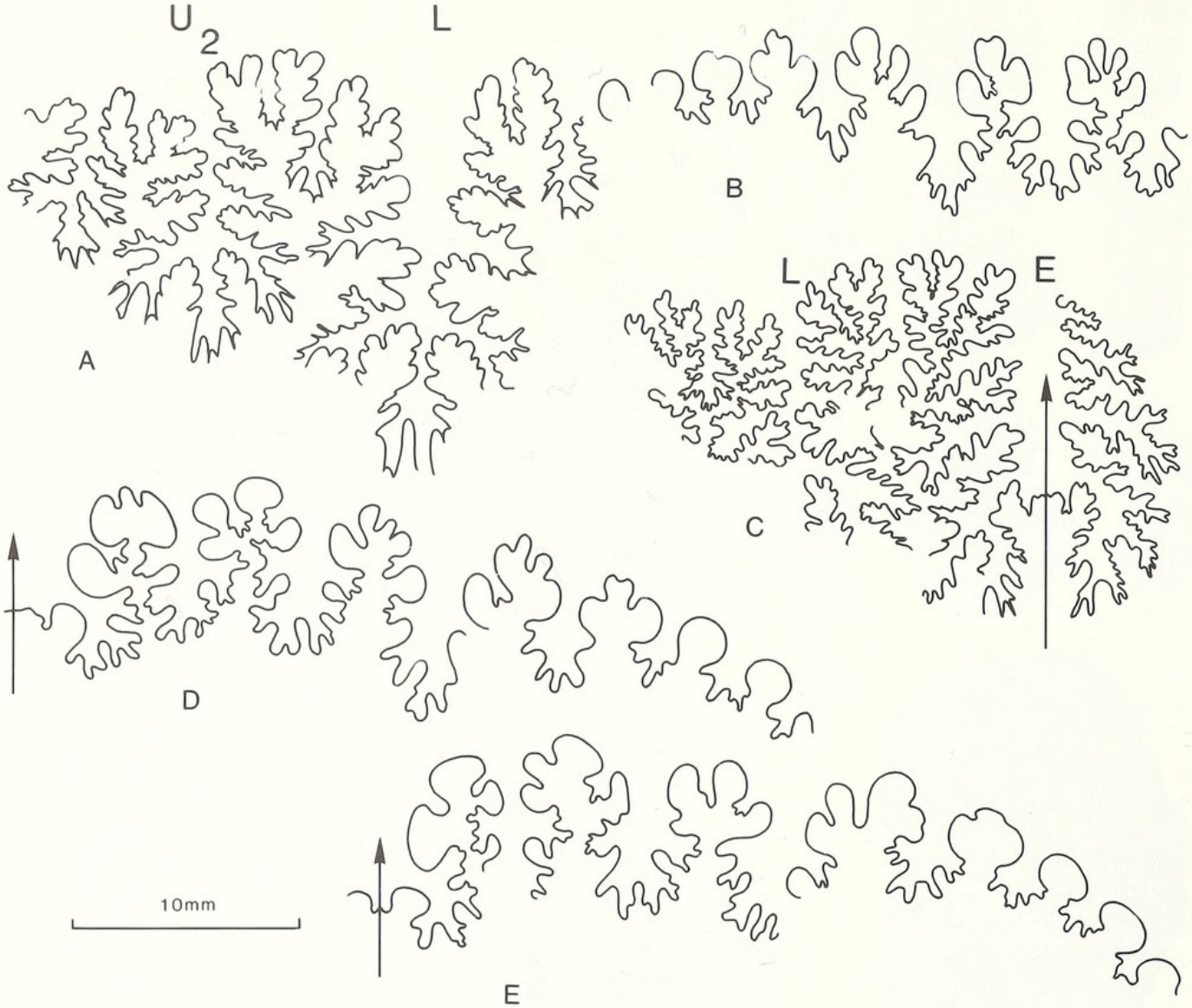
All specimens from the Valudavur Formation of Pondicherry, south India. All × 1.



KENNEDY and HENDERSON, *Brahmaites*

Subgenus ANABRAHMAITES Yabe and Shimizu, 1924, p. 79
[= *Subbrahmaites* Yabe and Shimizu, 1924, p. 75]

Type species. Ammonites Vishnu Forbes, 1846, p. 100, pl. 7, fig. 9.



TEXT-FIG. 6. Sutures of A, *Pachydiscus* (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858), the lectotype of *Ammonites chrishna*, Forbes, 1846, BMNH C51041. B, D, E, *Sphenodiscus siva* (Forbes, 1846). B, D, BMNH C51088, E, BMNH C51087, C, *Menuites menu* (Forbes, 1846), BMNH C47550.

EXPLANATION OF PLATE 10

Figs 1–2. *Pachydiscus* (*Pachydiscus*) sp. juv., cf. *neubergicus neubergicus* (Hauer, 1858). BMNH C51062, a paralectotype of *Ammonites Varuna* Forbes, 1846.

Figs 3–4. *Pachydiscus* (*Pachydiscus*) *yama* (Forbes, 1846). BMNH C51040, the holotype.

Fig. 5. *Brahmaites* (*Anabrahmaites*) *vishnu* (Forbes, 1846). BMNH C51027, a paralectotype.

Figs 6–8. *Pachydiscus* (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858). BMNH C51047, a paralectotype of *Ammonites Chrishna* Forbes, 1846.

All specimens from the Valudavur Formation of Pondicherry, south India. Figs 1–4 ×2; figs 5–8 ×1.

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KENNEDY and HENDERSON, *Pachydiscus*, *Brahmaites*

Diagnosis. *Brahmaites* in which umbilical bullae are lacking, whorls equidimensional or weakly compressed, and ribs simple and annular, closely spaced in early growth but widely separated at maturity, with siphonal tubercles.

Discussion. Whorl proportions, lack of bullae and ribbing style set *Anabrahmaites* apart from *Brahmaites*, and we afford it subgeneric status. *Subbrahmaites* Yabe and Shimizu, 1924 (p. 75), with *Brahmaites sachalinensis* Yabe and Shimizu, 1924 (p. 78, pl. 13, figs 1–4 as type species) is regarded as a synonym of *Anabrahmaites*.

Occurrence. Maastrichtian of south India, southwestern France, northern Spain, Armenia, Sakhalin, and Madagascar.

Brahmaites (*Anabrahmaites*) *vishnu* (Forbes, 1846)

Plate 6, figs 25–26; Plate 9, figs 5–7, 17–20; Plate 10, fig. 5; Plate 17, figs 8, 10–11

1846 *Ammonites Vishnu* Forbes, p. 100, pl. 7, fig. 9.
1850 *Ammonites Vishnu* Forbes; d'Orbigny, p. 213.
1865 *Ammonites Vishnu* Stoliczka, p. 164, pl. 79, fig. 5.
1891 *Puzosia haugi* Seunes, p. 20, pl. 15 (6), fig. 1.
1894 *Gaudryceras planorbiforme* J. Böhm sp.; de Grossouvre [*pars*], p. 231, pl. 34, figs 4–5; pl. 35, fig. 7 [*non* pl. 27, fig. 2, a gaudryceratid].
1897 *Brahmaites vishnu* Forbes sp.; Kossmat, p. 46 (153), pl. 8 (19), fig. 10.
1938 *Brahmaites haugi* Seunes; Collignon, p. 45, pl. 7, fig. 3.
1970 *Brahmaites vishnu* (Forbes); Atabekian and Akopian, p. 37, pl. 2, fig. 6.

Types. Lectotype, here designated, is BMNH C51026, the original of Forbes (1846, pl. 7, fig. 9; GSC R10456); BMNH C51027 is a paralectotype; BMNH C51028 was found with the types of *Ammonites garuda*; all are from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). Topotypes are BMNH 24192 (*ex* Kaye Collection), and BMNH 83624*a* (*ex* Marsham Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51028	11·0 (100)	5·5 (50·0)	2·8 (25·5)	1·96	3·8 (34·5)
BMNH 24192	73·5 (100)	24·2 (32·9)	21·5 (29·3)	1·13	33·0 (44·9)
BMNH 83624a	95·0 (100)	34·0 (35·8)	29·0 (30·5)	1·17	45·0 (47·4)
BMNH C51027	100·0 (100)	31·0 (31·0)	31·5 (31·5)	0·98	44·0 (44·0)
BMNH C51026	107·0 (100)	31·5 (29·4)	32·0 (29·9)	0·98	49·0 (45·8)

Description. The earliest growth stages seen are represented by BMNH C51028 (Pl. 9, figs 5–7), a juvenile 11 mm in diameter. The shell is moderately evolute, with a depressed reniform whorl section, and a near-smooth surface with distant prorsiradiate constrictions, with an associated collar-rib. The inner whorls of larger specimens show coiling to have been more evolute, serpenticone, and ornamented only by growth lines, distant constrictions and associated collar-ribs to a diameter of 20 mm. Beyond this, coiling continues to be very evolute, with a broad, shallow umbilicus (U = 44–47%), the umbilical wall convex and sloping outwards from the umbilical seam, and merging with a poorly defined umbilical shoulder. The flanks are flattened, and the ventrolateral shoulders and venter broadly rounded. Weak, distant even ribs appear from 20 mm diameter onwards, and arise at the umbilical shoulder, are prorsiradiate and straight to feebly convex on the flanks, effacing on the outer flank and numbering around 40 per whorl. From about 50 mm diameter onwards the ribs coarsen markedly and are of variable strength and spacing, numbering around 20 per whorl. They are narrow, straight to feebly convex, prorsiradiate and annular, weak on the inner flank but strong on the outer flank and ventrolateral shoulders, and weakening over the siphonal region. The ribs weaken markedly on the last part

EXPLANATION OF PLATE 11

Figs 1–3. *Pachydiscus* (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858). BMNH C51041, the lectotype of *Ammonites Chrishna* Forbes, 1846; Valudavur Formation; Pondicherry, south India, ×1.

3

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1

KENNEDY and HENDERSON, *Pachydiscus* (*Pachydiscus*)

of the adult shell. Prominent constrictions are present at all ontogenetic stages, generally numbering three per whorl. They are narrow and deep, feebly rursiradiate on the umbilical wall, deeply incised into the umbilical shoulder, and straight and prorsiradiate on the flanks, crossing the venter near-straight and transverse. Each is preceded by a collar, which increases in strength through ontogeny, becoming very coarse in adults, with feeble bullae in some cases. There is a coarse siphonal tubercle, which extends from the rib to interrupt the constriction (Pl. 6, fig. 25; Pl. 9, fig. 19). Suture complex, with L as deep as E and trifid, U trifid, and the umbilical lobe strongly retracted.

Discussion. We can see no significant differences between the holotype of *Puzosia haugi* of Seunes (1891), and the Indian types, apart from differences in preservation, the former, shown in Pl. 17, figs 8, 10, 11, being a composite mould. *P. haugi* was regarded as a synonym to *Gaudryceras planorbiforme* of Böhm (1891, pl. 1, figs 11–12) by de Grossouvre (1894, p. 231), but this is a gaudryceratid, as is de Grossouvre's Tercis specimen (1894, pl. 27, fig. 2). *Anabrahmatites sachalinensis* Yabe and Shimizu, 1924 (p. 78, pl. 13, figs 1–4) is even more distantly ribbed than the present species when adult, and lacks the closely ribbed middle growth stage. *Brahmaites mikobokensis* Collignon, 1971 (p. 22, pl. 647, figs 2400–2401) has densely and evenly ribbed, depressed reniform whorls in middle and later growth, with incipient umbilical bullae on internal moulds, the ribbing effacing over the venter, with no siphonal tubercles on internal moulds.

Occurrence. Maastrichtian, south India, Madagascar, south-western France and northern Spain.

Family PACHYDISCIDAE Spath, 1922, p. 132

Discussion. See Kennedy (1986*b*, p. 30) for a review of the nomenclature problems associated with the dimorphism present in the family.

Genus PACHYDISCUS Zittel, 1884, p. 466
Subgenus PACHYDISCUS Zittel, 1884, p. 466

Type species. Ammonites neubergicus Hauer, 1858, p. 12, pl. 2, figs 1–3; pl. 3, figs 1–2, by the subsequent designation of de Grossouvre 1894, p. 177.

Discussion. See Kennedy and Summesberger (1986, p. 188), and Kennedy (1986*b*, p. 34).

Pachydiscus (*Pachydiscus*) *neubergicus neubergicus* (Hauer, 1858)

Plate 10, figs 6–8; Plate 11; Text fig 6A

1846 *Ammonites Chrishna* Forbes, p. 103, pl. 9, fig. 2.
1850 *Ammonites Chrishna* Forbes; d'Orbigny, p. 213.

EXPLANATION OF PLATE 12

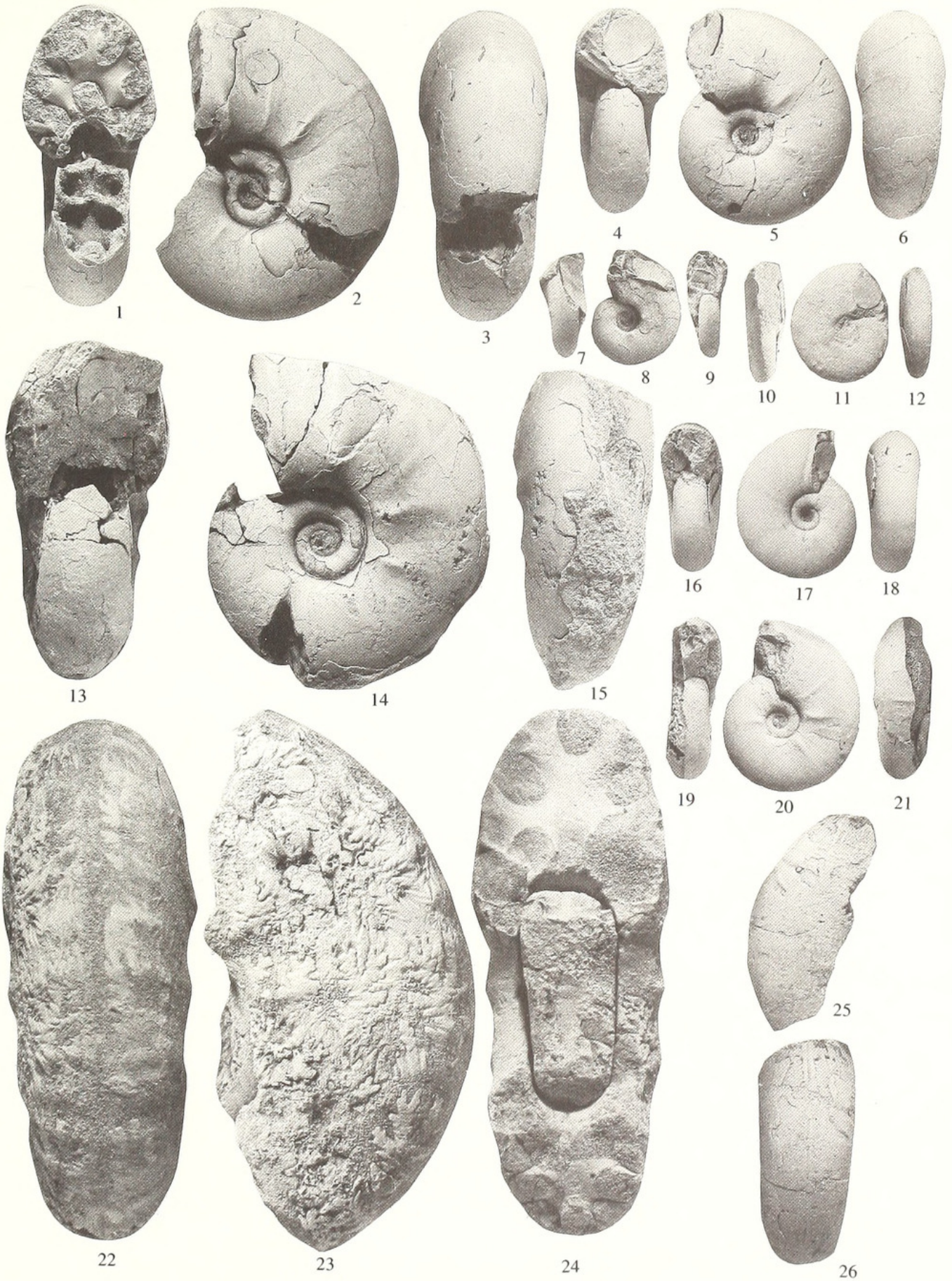
Figs 1–6, 13–15, 19–26. *Pachydiscus* (*Pachydiscus*) *egertoni* (Forbes, 1846). 1–3, BMNH C41042, the lectotype of *Ammonites Ganesa* Forbes, 1846. 4–6, BMNH C51045, a syntype of *Ammonites Ganesa* Forbes, 1846. 13–15, BMNH C51044, a possible syntype of *Ammonites Ganesa* Forbes, 1846. 19–21, BMNH C51046, a syntype of *Ammonites Ganesa* Forbes, 1846, 22–26, BMNH C51043, a paralectotype.

Figs 7–9. *Pachydiscus* (*Pachydiscus*) sp. juv. cf. *neubergicus neubergicus* (Hauer, 1858). BMNH C51062, a syntype of *Ammonites Varuna* Forbes, 1846.

Figs 10–12. *Pachydiscus* (*Pachydiscus*) *yama* (Forbes, 1846). BMNH C51040, the holotype.

Figs 16–18. *Pachydiscus* (*Neodesmoceras*) *soma* (Forbes, 1846). BMNH C51039, the holotype.

All specimens from the Valudavur Formation of Pondicherry, south India. All × 1.



KENNEDY and HENDERSON, *Pachydiscus*

1858 *Ammonites Neubergicus* Hauer [*pars*], p. 12, pl. 2, figs 1–3, [*non* pl. 3, figs 1–2 = *Pachydiscus haueri* Collignon, 1952].
1986 *Pachydiscus* (*Pachydiscus*) *neubergicus* (Hauer, 1858); Kennedy and Summesberger, p. 189, pl. 2, figs 1–2; pl. 3, figs 1–3; pl. 4, figs 1–5; pl. 5, figs 1, 4–5; pl. 6, figs 1–2, 5; pl. 15, figs 7–8; text-fig. 5*a–b* [with full synonymy].
1986*c* *Pachydiscus* (*Pachydiscus*) *neubergicus* (Hauer, 1858); Kennedy, p. 34, pl. 4, fig. 3.
1986 *Ammonites neubergicus* Hauer, 1858; Henderson and Kennedy, p. 277.
1986 *Ammonites chrishna* Forbes, 1846; Henderson and Kennedy, p. 277.
1986 *Pachydiscus chrishna* (Forbes, 1846); Matsumoto in Matsumoto *et al.*, p. 8.

Types. The lectotype of *P.* (*P.*) *neubergicus* is no. 1858.01.6, in the collection of the Geologische Bundesanstalt, Vienna, and is the original of Hauer 1858 (p. 12, pl. 2, figs 1–2). There are three paralectotypes with the same registration number. All are from the Maastrichtian of Neuberg, Steiremark, Austria. The lectotype, here designated, of *Ammonites chrishna* is BMNH C51038, the original of Forbes (1846, pl. 9, fig. 2; GSC R10479); paralectotypes are BMNH C51043 and C51047. All are from the Valudavur Formation of Pondicherry, South India (*ex* Kaye and Cunliffe Collection).

Under the plenary powers of the International Commission on Zoological Nomenclature, *Ammonites neubergicus* Hauer, 1858, is given precedence over *Ammonites chrishna* Forbes, 1846, whenever the two names are considered to be synonyms (ICZN Opinion 1519, 1989).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51041	115·5 (100)	33·3 (28·8)	45·5 (39·4)	0·73	33·2 (28·7)

Description. What may be the early growth stages of this species are represented by BMNH C51062, one of the type series of *Ammonites varuna* (Pl. 10, figs 1–2; Pl. 12, figs 7–9). It is 12 mm in diameter, moderately involute with a small, shallow umbilicus, compressed whorls (whorl breadth to height ratio 0·75 approximately) and five umbilical bullae on the outer whorl. BMNH C51038, the lectotype of *P.* (*P.*) *chrishna*, is very well preserved, retaining much of its original shell and over half a whorl of body chamber; it seems to be a near-complete adult. Coiling is fairly involute, with about 50% of the previous whorl covered, the umbilicus comprising 28·7% of the diameter, shallow, with a low umbilical wall, sloping outwards from the umbilical seam to a well-rounded umbilical shoulder. The whorl section is compressed, with a whorl breadth to height ratio of 0·73, the greatest breadth around mid-flank, the flanks weakly convex, converging to a rounded venter. There are two orders of ribs on the phragmocone and early body chamber; primaries, which efface on the outer flank but which may be tenuously linked to pairs of secondaries, and secondary ribs confined to the ventrolateral shoulders and venter. The primary ribs are rursiradiate and concave on the umbilical wall and shoulder, and straight and recti- to feebly prorsiradiate on the flanks. They strengthen into long umbilical bullae, and are very distant, numbering 12 per whorl on the last whorl of the phragmocone, and 14 on the outer whorl of the specimen. Secondary ribs arise on the ventrolateral shoulders, are markedly prorsiradiate, concave on the shoulders, strengthened and more or less transverse on the venter, effacing somewhat over the siphuncle. They disappear at a diameter of 95 mm, and number 28 on the last half whorl on which they are present. Suture typical for genus, with L and the first minor lobe on the retracted umbilical lobe trifid.

Discussion. The figured paralectotype (Pl. 10, figs 6–8) is rather worn, but conforms well with the lectotype. The types and additional topotype material of *P.* (*P.*) *neubergicus neubergicus* were described and illustrated at length by Kennedy and Summesberger (1986), who discussed differences from other species, and showed *neubergicus* and *chrishna* to represent one and the same species. Differences between *P.* (*P.*) *neubergicus* and other species were also discussed by Kennedy (1986*c*). *P.* (*P.*) *neubergicus dissitus* Henderson and McNamara, 1985 (p. 72, pl. 7, figs 7, 9; pl. 10, figs 3–6; text-figs 11, 12*e*, 13*c*) has inner whorls indistinguishable from those of *P.* (*P.*) *neubergicus*

EXPLANATION OF PLATE 13

Figs 1–3. *Pachydiscus* (*Pachydiscus*) *egertoni* (Forbes, 1846). BMNH C51038, the lectotype; Valudavur Formation; Pondicherry, south India, ×1.

KENNEDY and HENDERSON, *Pachydiscus* (*Pachydiscus*)

neubergicus (e.g. compare text-fig. 11 in Henderson and McNamara 1985 with Pl. 11, fig. 2 herein). But from a diameter of 85–95 mm onwards, there is an utterly distinct ornament on the late phragmocone of *dissitus* (body chambers are unknown) with many more ventral than umbilical ribs, the subspecies coming to resemble *P.* (*P.*) *gollevillensis* (d'Orbigny, 1850) where, however, this dense ventral ribbing occurs throughout ontogeny.

Occurrence. Low Lower to low Upper Maastrichtian of northern Spain, southwestern France, north Germany, Denmark, Poland, Austria, European Russia, the Ukrainian SSR, the Armenian SSR, Zululand (South Africa), Nigeria, Madagascar, Brazil and South India. Subspecies *dissitus* is known only from the Upper Maastrichtian of Western Australia.

Pachydiscus (*Pachydiscus*) *egertoni* (Forbes, 1846)

Plate 12, figs 1–6, 13–15, 19–26; Plate 13, figs 1–3; Text-fig 4B

1846 *Ammonites Egertoni* Forbes, p. 108, pl. 9, fig. 1.
1846 *Ammonites Ganesa* Forbes, p. 103, pl. 7, fig. 8.
1850 *Ammonites Chrishna* Forbes; d'Orbigny [*pars*], p. 213.
1864 *Ammonites Egertoni* Forbes; Stoliczka [*pars*], p. 104, [*non* pl. 53, fig. 1 = *P.* (*P.*) *preegertoni* Collignon, 1955, according to Matsumoto *in* Matsumoto *et al.*, 1986]; *nec* pl. 53, fig. 2 = *Pseudomenuites stoliczkai* Matsumoto *in* Matsumoto *et al.*, 1986; ?pl. 53, fig. 3 (suture only); *nec* pl. 53, fig. 4 = *P.* (*P.*) *neubergicus neubergicus*.
1864 *Ammonites ganesa* Forbes; Stoliczka, p. 106, pl. 54, fig. 2.
1898 *Pachydiscus ganesa* Forbes sp.; Kossmat, p. 96 (161), pl. 15 (21), fig. 2.
?*non* 1898 *Pachydiscus egertonianus* Forbes sp.; Kossmat, p. 94 (159), pl. 15 (21), fig. 4.
1959*a* *Pachydiscus egertoni* (Forbes); Matsumoto, p. 42, text-fig. 17.
1959*a* *Pachydiscus* (s.s.) cf. *egertoni* (Forbes); Matsumoto [*pars*], p. 42, text-fig. 18 only.
1959*a* *Ammonites ganesa* Forbes; Matsumoto, p. 45, text-fig. 18.
?1985 *Pachydiscus* (*Pachydiscus*) *egertoni* (Forbes, 1846); Zaborski, p. 19, text-fig. 19.
1986 *Ammonites egertoni* Forbes, 1846; Matsumoto *in* Matsumoto *et al.*, p. 7, text-fig. 2.
1986 *Pachydiscus*; Kennedy, text-fig. 18*e*.

Types. Lectotype, designated by Matsumoto, 1959*a* (p. 42), is BMNH C51038, the original of Forbes, 1846 (pl. 9, fig. 1; GSC R10479); BMNH C51043 is a paralectotype. The lectotype, here designated, of *Ammonites Ganesa* Forbes, 1846, is BMNH C51042, the original of Forbes (1846, pl. 7, fig. 8; GSC R10465); paralectotypes are BMNH C51044–51046. BMNH C51047 is also believed to be a paralectotype, although questioned by Matsumoto (1959*a*, p. 42). All are from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C57046	29·0 (100)	13·5 (46·6)	12·8 (44·1)	1·05	7·8 (26·9)
BMNH C51044	43·8 (100)	18·8 (42·9)	18·5 (42·2)	1·02	12·0 (27·3)
BMNH C51042	45·0 (100)	18·8 (41·8)	18·5 (41·1)	1·02	12·5 (27·7)
BMNH C51038	103·0 (100)	38·0 (36·9)	43·0 (41·7)	0·88	28·5 (27·7)

Description. The lectotype and paralectotype of *P.* (*P.*) *egertoni* are both phragmocones, the former retaining traces of shell, the latter an internal mould. The coiling is moderately involute, with U = 27·7% of diameter. The umbilicus is of moderate depth, the wall initially steep, but sloping outwards thereafter to a gently rounded

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EXPLANATION OF PLATE 14

Figs 1–15. *Menuites menu* (Forbes, 1846). 1–2, BMNH C47551, a paralectotype. 3–5, BMNH C47550, a paralectotype. 6–9, two BMNH unregistered syntypes. 10–12, BMNH C47549, a paralectotype. 13–15, BMNH C51048, the lectotype.

All specimens from the Valudavur Formation of Pondicherry, south India. Figs 1–5, 10–15 × 1; figs 6–9 × 2.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

KENNEDY and HENDERSON, *Menuites*

umbilical shoulder. The lectotype has a whorl breadth to height ratio of 0·88 at a diameter of 103 mm. The greatest breadth is below mid-flank, the inner flanks broadly rounded, the outer flanks becoming progressively more convergent as size increases, so that the venter becomes progressively more narrowly rounded.

Juveniles, to a diameter of 45 mm, have 7 or 8 primary ribs per whorl, expanded into umbilical bullae, straight and prorsiradiate on the inner flanks, effacing on the outer. Non-bullate primaries are sometimes intercalated between the bullate ones at this growth stage. Secondary ribs are restricted to the outer flanks and venter, and are only transiently developed, being absent below 45 mm diameter and disappearing at 65 mm diameter in the lectotype; two secondaries separate the primaries at this stage. The lectotype has 12 distant rectiradiate primary ribs on the outer whorl, those on the last part extending to the ventrolateral shoulder but weakening and effacing over the venter. Suture (Text-fig. 4B) typical for subgenus, with deep trifid L and U retracted on umbilical wall.

Discussion. The syntypes of *Ammonites Ganesa* of Forbes (Pl. 12, figs 1–6, 13–15, 19–21) are juvenile *P.* (*P.*) *egertoni*, although one, BMNH C51046 (Pl. 12, figs 19–21) has stronger ventral ribbing than the others. It has two thirds of a whorl of body chamber, and a weak terminal constriction. *P.* (*P.*) *egertoni* and *P.* (*P.*) *jacquoti jacquoti* (Seunes, 1890*b*) (p. 5, pl. 3 (2), figs 1–3; see revision in Kennedy 1986*c*; p. 34, pl. 5, figs 3–11, 15–19; pl. 6; text-figs 2*d–e*; 3*o*, *s*; 4*b*) are closely allied, and Atabekian and Akopian (1969) regarded them as no more than subspecifically distinct. The umbilicus of *egertoni* is smaller, whorls higher with a lower whorl breadth to height ratio, the whorl sides convergent rather than subparallel, with ornament declining from a much smaller diameter. *P.* (*P.*) *jacquoti australis* Henderson and McNamara, 1985 (p. 76, pl. 8, figs 1–2, 7–10*a*; text-figs 12*a*, 13*b*, 14, 15*a*) is a coarser ribbed form that retains secondary ribs to a large diameter; *P.* (*P.*) *jacquoti chilensis* Stinnisbeck, 1986 (p. 218, pl. 13, fig. 8; pl. 15, figs 1, 3; text-fig. 28*a*) seems to be a synonym. Of specimens referred to *Ammonites egertoni* by Stoliczka (1864), his plate 53, figure 1 is *P.* (*P.*) *preegertoni* Collignon, 1955, according to Matsumoto (*in* Matsumoto *et al.*, 1986), plate 53, figure 2 is the holotype of *Pseudomenuites stoliczkai* Matsumoto, 1986 (*in* Matsumoto *et al.*, 1986, p. 10, text-fig. 5), while the specimen shown in Stoliczka's plate 53, figure 4 seems to be a fragment of *P.* (*P.*) *neubergicus neubergicus*. The fragment illustrated by Kossmat (1898, pl. 15 (21), fig. 4) is coarsely ribbed, and may be a *P.* (*P.*) *jacquoti*.

Occurrence. Maastrichtian, south India.

Pachydiscus (*Pachydiscus*) *yama* (Forbes, 1846)

Plate 10, figs 3–4; Plate 12, figs 10–12

1846 *Ammonites Yama* Forbes, p. 107, pl. 7, fig. 4.
1850 *Ammonites Chrishna* Forbes; d'Orbigny [*pars*], p. 213.
non 1865 *Ammonites Yama* Forbes; Stoliczka, p. 120, pl. 59, fig. 12.

Type. Holotype, by monotypy, is BMNH C51040, the original of Forbes (1846, pl. 7, fig. 4; GSC R10473), from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51040	16·8 (100)	5·2 (31·0)	7·0 (41·6)	0·74	4·0 (23·8)

EXPLANATION OF PLATE 15

Figs 1–2. *Phylloceras* (*Neophylloceras*) *nera* (Forbes, 1846). BMNH C22681, holotype.
Fig. 3. *Phylloceras* (*Neophylloceras*?) *decipiens* Kossmat, 1895. BMNH C51080, holotype.
Figs 4–5. *Phylloceras* (*Neophylloceras*) *nera* (Forbes, 1846). BMNH C51076, paralectotype.
Figs 6–13. *Sphenodiscus siva* (Forbes, 1846). 6–9, BMNH C51088, paralectotype. 10–13, BMNH C51087, lectotype.
All specimens from the Valudavur Formation of Pondicherry, south India. Figs 1–5 ×2; figs 6–13 ×1.

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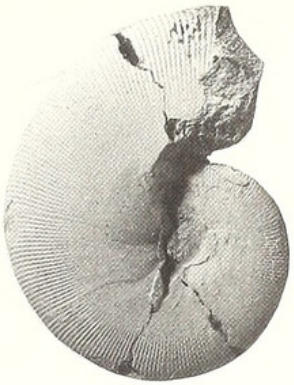

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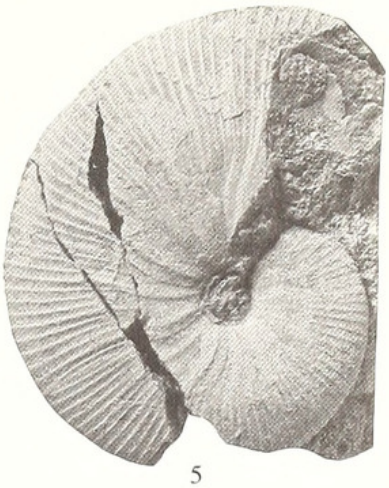

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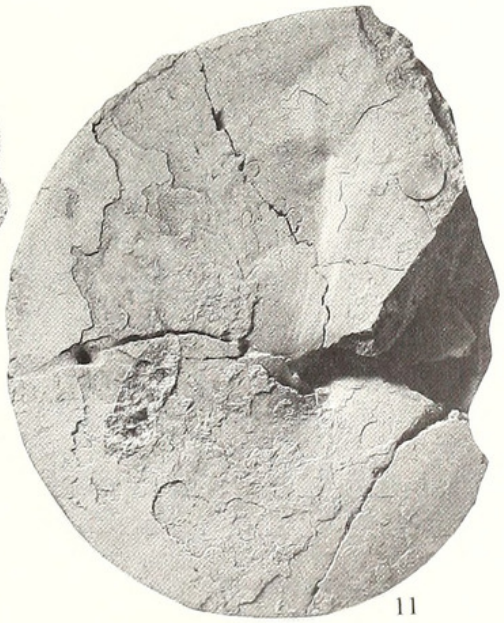

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KENNEDY and HENDERSON, *Phylloceras*, *Sphenodiscus*

Description. The holotype is a juvenile with some test preserved, and septate. Coiling is moderately involute, with U = 23·8%, shallow, with a low, steep but not vertical wall and narrowly rounded umbilical shoulder. The whorls are compressed, with whorl breadth to height ratio 0·74, the flanks feebly convex, converging to a narrowly rounded venter. The shell is smooth, but for a feeble bulla at the largest diameter preserved. Part only of the suture is visible; it is of moderate complexity, with L trifid and U retracted on the umbilical wall.

Discussion. What seems to be the same species is represented by one of the types of *Ammonites varuna*, BMNH C51062 (Pl. 5, figs 21–23). These specimens, by their sutures and (in the holotype of *yama*) presence of umbilical bullae, are juvenile *Pachydiscus* (*Pachydiscus*). There are close similarities to nuclei of *P.* (*P.*) *gollevillensis* (d'Orbigny, 1850) dissected from larger specimens (e.g. Kennedy 1986*c*, pl. 11, figs 1–3), but it is perfectly possible that they belong to any one of a number of Maastrichtian *P.* (*Pachydiscus*), including *P.* (*P.*) *neubergicus* and subspecies (as suggested by d'Orbigny 1850, p. 213, and by juveniles from Zululand (South Africa) in the collections of the Natural History Museum, London) or *P.* (*P.*) *compressus* Spath, 1922. *P.* (*P.*) *yama* should, in our view, be treated as a *nomen dubium*. The specimen referred to this species by Stoliczka (1865, p. 120, p. 59, fig. 12) is a much stouter shell, from north-east of Odium, south India (in the text: Coonum in the Trichinopoly Group in the explanation of the plate).

Occurrence. As for type.

Subgenus NEODESMOCERAS Matsumoto, 1947, p. 39

Type species. Pachydiscus (*Neodesmoceras*) *japonicus* Matsumoto, 1947, p. 39, by original designation.

Pachydiscus (*Neodesmoceras*) *soma* (Forbes, 1846)

Plate 12, figs 16–18; Text-fig. 3G

1846 *Ammonites Soma* Forbes, p. 102, pl. 7, fig. 7.
1850 *Ammonites Chrishna* Forbes; d'Orbigny [*pars*], p. 213.
1986 *Ammonites soma* Forbes; Matsumoto, *in* Matsumoto *et al.*, p. 9, text-fig. 4.

Type. Holotype, by monotypy, is BMNH C51039, the original of Forbes (1846, pl. 7, fig. 7; GSC R1046 3), from the Valudavur Formation of Pondicherry, south India.

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51039	21·5 (100)	8·2 (38·1)	8·5 (39·5)	0·96	5·2 (24·2)

Description. The holotype is a juvenile, with over half a whorl of body chamber preserved, and retaining much of the original shell. Coiling is fairly involute, with U = 24% of diameter, shallow, with an initially vertical, thereafter outward-inclined umbilical wall, with well rounded shoulder. The flanks are feebly convex and subparallel, the venter broadly rounded, with whorl breadth to height ratio 0·96, the greatest breadth below mid-flank. There are three feeble umbilical bullae on the last whorl of phragmocone. The adapertural half of the body chamber bears four weak, irregularly spaced constrictions, of which the last is the strongest. They are rursiradiate on the umbilical wall, straightening on the umbilical shoulder, prorsiradiate and feebly flexuous on the flanks, projected forward on the ventrolateral shoulder, and feebly convex on the venter. They are

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EXPLANATION OF PLATE 16

Figs 1–3, 7–8. *Desmophyllites diphylloides* (Forbes, 1846). 1–2, BMNH C22682, lectotype. 3, 7–8, BMNH C22683, paralectotype. Both specimens are from the Valudavur Group of Pondicherry, south India.

Figs 4–6, 9–12. *Saghalinites wrighti* Birkelund, 1965. 4, 12, MGUH 1964.110. 5–6, MGUH 1964.100.9, MGUH 1964.121. 10–11, MGUH 1964.117.

All specimens from the Maastrichtian fauna reworked into the oyster–ammonite conglomerate at the base of the Palaeocene at Nûgssuaq, west Greenland, and in the collections of the Geologisk Museum, Copenhagen. Figs 1–3, 7–8 ×2; figs 4–6, 9–12 ×1.

KENNEDY and HENDERSON, *Desmophyllites*, *Saghalinites*

succeeded by delicate ventral ribs. The constriction next to the aperture has a delicate rib that extends to the umbilicus. Suture with L and U, trifid, U only slightly retracted on the umbilical wall (Text-fig. 3G).

Discussion. Both Stoliczka (1864, p. 106) and Kossmat (1898, p. 94 (159)) regarded Forbes's *Ammonites Soma* as a juvenile of *Ammonites Ganesa*, and thus a synonym of *P.* (*Pachydiscus*) *egertoni*. But juveniles of the latter are different in both cross-section and ribbing style (e.g. compare Pl. 12, figs 16–18 with Pl. 12, figs 7–9, 19–21). *Ammonites soma* is a juvenile *Pachydiscus* (*Neodesmoceras*) in our view, rather than a *P.* (*Pachydiscus*), as proposed by both Spath (1953, p. 39) and Matsumoto (*in* Matsumoto *et al.*, 1979, p. 10). The general shell shape is similar to that of *P.* (*N.*) *gracilis* Matsumoto, 1979 (*in* Matsumoto *et al.*, 1979, p. 60, notably pl. 10, fig. 2), and juvenile *P.* (*N.*) *mokotibense* Collignon, 1952 (p. 81, pl. 28, fig. 2) from Zululand (South Africa) in the collections of the British Museum (Natural History). These species have stouter, more massive shells, with well-developed, distant ventral ribs when young.

Occurrence. As for type.

Genus MENUITES Spath, 1922, p. 123

[= *Besairieites* Collignon, 1931, p. 19; ?*Anapachydiscus* Yabe and Shimizu, 1926, p. 172]

Type species. Ammonites Menu Forbes, 1846, p. 111, pl. 10, fig. 1, by original designation.

Discussion. Menuites has as type species a small form, constricted and bituberculate on the early part of the adult body chamber, and with a markedly constricted adult aperture. Such small forms occur in the same zone of the Upper Campanian of northern Hokkaido (Matsumoto 1984, p. 17, pl. 5, fig. 1; text-fig. 5; *Menuites sandai* Matsumoto, 1984) with typical large specimens of the type species of *Anapachydiscus*, *A. fascicostatus* (Yabe, 1921) (Matsumoto 1984, p. 14, pl. 4, figs 1–2; pl. 5, fig. 2; pl. 8, fig. 7; text-fig. 4), and have identical early whorls. There seems little doubt that these are dimorphs. But since the macroconchs of *Menuites menu* have yet to be recognized, and might be different from macroconch *Anapachydiscus*, they cannot be yet confirmed as synonyms.

Menuites menu (Forbes, 1846)

Plate 14, figs 1–15; Text-fig. 6C

1846 *Ammonites Menu* Forbes, p. 111, pl. 10, fig. 1.
1850 *Ammonites Menu* Forbes; d'Orbigny, p. 213.

EXPLANATION OF PLATE 17

Fig. 1. *Hauericeras rembda* (Forbes, 1846). BMNH C51025, paralectotype; Valudavur Group; Pondicherry, south India.

Figs 2–3. *Zelandites varuna* (Forbes, 1846). BMNH C51059; lectotype, Valudavur Group; Pondicherry, south India.

Figs 4–7. *Desmophyllites diphylloides* (Forbes, 1846). 4, 7, KW21, Oxford University Museum Collections; Upper Maastrichtian Miria Formation Giralia Range, Western Australia. 5–6, BMNH C51020, the largest paralectotype; Valudavur Group; Pondicherry, south India.

Figs 8–9. *Brahmaites* (*Anabrahmaites*) *vishnu* (Forbes, 1846). The holotype of *Puzosia haugi* Seunes, 1891 (pl. 15 (6), fig. 1); Upper Maastrichtian; between Gan and Rébénacq, Pyrénées Atlantiques, France; in the Sorbonne Collections, now housed in the Université Paris VI.

Fig. 10. *Desmophyllites larteti* (Seunes, 1891). The original of Seunes (1891, pl. 13 (4, fig. 2); Upper Maastrichtian; between Gan and Rébénacq, Pyrénées Atlantiques, France; now housed in the Université Paris VI.

Figs 1–3 ×2; figs 4–11 ×1.

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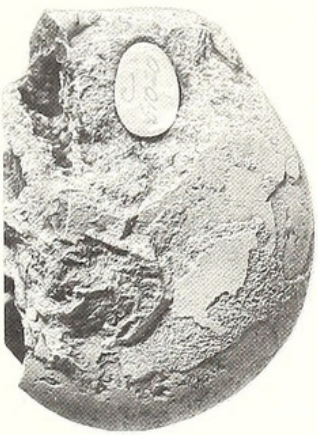

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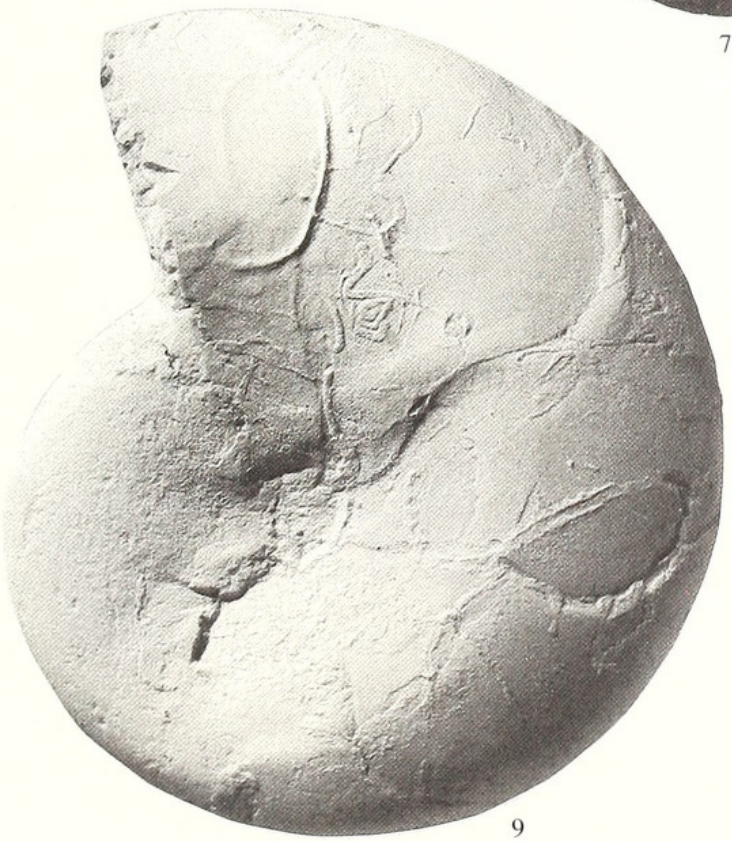

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KENNEDY and HENDERSON, Indian, French and Australian Maastrichtian ammonites

1864 *Ammonites Menu* Forbes; Stoliczka [*pars*], p. 103, pl. 52, fig. 4, [*non* fig. 3 = *Pachydiscus Cricki* Kossmat, 1898].
1898 *Pachydiscus Menu* Forbes sp.; Kossmat, p. 104 (169).
1922 *Menuites menu* (Forbes); Spath, p. 123.
1955 *Menuites menu* (Forbes); Matsumoto, p. 158.
1957 *Menuites menu* (Forbes); Wright, p. L380, fig. 406.1.
1977 *Menuites menu*; Kennedy, text-fig. 19.

Types. Lectotype, designated by Matsumoto 1955 (p. 158) is BMNH C51048, the original of Forbes (1846, pl. 10, fig. 1*a–b*; GSC R10482); paralectotypes are BMNH C47549–47550 (probably the original of Forbes 1846, pl. 10, fig. 1*c*), BMNH C47551, and three unnumbered nuclei, all from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection). Topotypes are BMNH C3566*a–b*, and BMNH C82500 (*ex* March Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C47551	34·2 (100)	22·0 (64·3)	14·4 (42·1)	1·53	8·8 (25·7)
BMNH C47549	61·5 (100)	35·0 (56·9)	26·8 (43·6)	1·31	15·5 (25·2)
BMNH C51048	69·8 (100)	37·8 (54·1)	28·0 (40·1)	1·06	18·8 (26·9)

Description. The lectotype and paralectotype BMNH C47549 are adults and are an estimated 68 mm and 71·5 mm in diameter respectively. Coiling is moderately involute, with U = 25 to 27% of diameter, the umbilicus deep, with a high convex wall, sloping outwards to a narrowly rounded umbilical shoulder. The whorl section is depressed reniform, with whorl breadth to height ratio 1·53 at the end of the phragmocone and 1·06–1·31 at the adult aperture. The flanks are strongly inflated, and the venter broadly arched. Prominent umbilical tubercles are present from a diameter of less than 15 mm, and number 11–13 per whorl; they are the flat-topped bases of umbilical spines, none of which survives on the phragmocones (Pl. 14, fig. 2). Fine, crowded irregular ribs, some only a little stronger than growth lines, arise in groups from the umbilical tubercles, and intercalate between the tubercles, covering, together with the prominent growth lines, the whole of the shell surface. They are rursiradiate on the umbilical wall, but straight and prorsiradiate on the flanks, flexing forwards on the ventro-lateral shoulder, and crossing the venter in a broad convexity. Strong ventro-lateral tubercles, which alternate in position on either side of the venter (Pl. 14, figs 10, 12–13, 15) are developed on the last part of the phragmocone and adapical part of the body chamber, appearing at a diameter of 40 mm. Ribbing weakens on the body chamber, which is densely lirate, and ventral tubercles are absent on the last 90–120°, the umbilical tubercles weakening progressively, but extending much closer to the aperture. Two constrictions are present on the lectotype (Pl. 14, figs 13–15), one 45° before and one immediately preceding the aperture. There is one constriction immediately preceding the aperture (as preserved) in BMNH C47549 (Pl. 14, fig. 11). The constrictions are broad, shallow, feebly concave and prorsiradiate on the flanks, sweeping forward on the ventrolateral shoulder, and crossing the venter in a broad, shallow convexity. They are preceded by a narrow, strong, feebly bullate collar-rib, and followed by a weaker, narrow rib. A short, smooth, tubular section of shell separates this rib from the mouth border. The suture (Text-fig. 6c) is florid with deep, narrow, trifid L; U is retracted on the umbilical wall.

What we take to be juveniles of the species are nuclei 7 mm or less in diameter (Pl. 14, figs 6–9); these are even more depressed than the later growth stages, and smooth. One phragmocone, BMNH C82500, shows interrupted growth lines on the venter, recording the site of mantle damage in life.

Discussion. *Menuites menu* is particularly distinguished by the very delicate ribbing, present through most of ontogeny. This alone separates it from species such as *Menuites portlocki* (Sharpe, 1855; p. 30, pl. 17, figs 2–3), from the Upper Campanian of western Europe; *Menuites complexus* Hall and Meek, 1856 (p. 394, pl. 4, fig. 1) from the Upper Campanian of the US Western Interior; *M.* ?aff.

EXPLANATION OF PLATE 18

Figs 1–6. *Desmophyllites larteti* (Seunes, 1891). 1–3, the original of Seunes (1891, pl. 13 (4), fig. 1). 4–6, the original of Seunes (1891, pl. 13 (4), fig. 2). From the Upper Maastrichtian between Gan and Rébénacq, Pyrénées Atlantiques, France; now housed in the Université Paris VI. All ×1.

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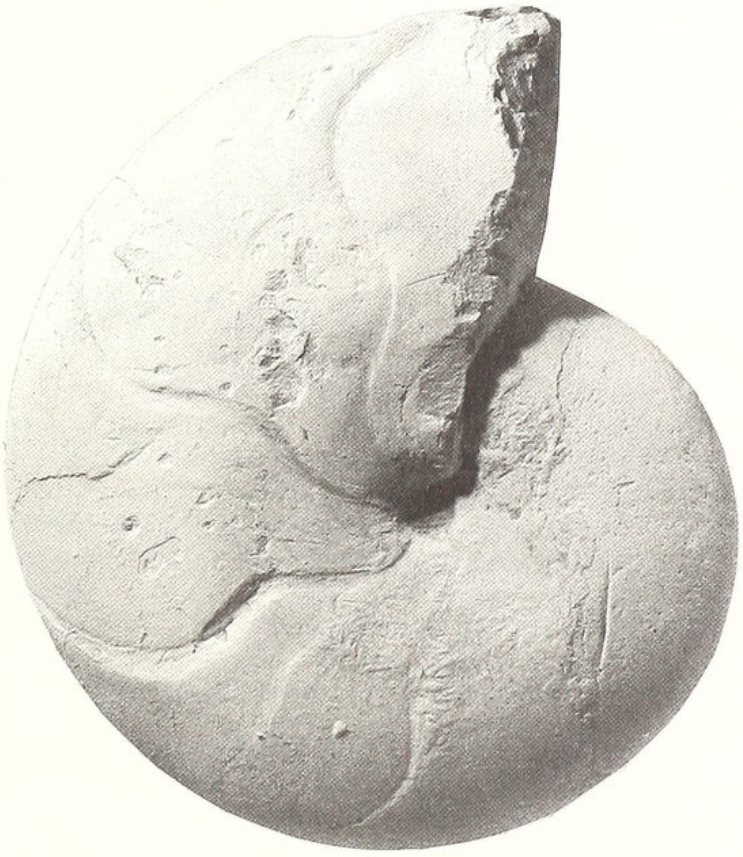

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KENNEDY and HENDERSON, *Desmophyllites*

complexus of Reeside (1962, p. 122, pl. 69, figs 1–6), from the Upper Campanian of New Jersey; *M. stephensoni* Young, 1963 (p. 57, pl. 15, figs 1–2; text-figs 7*o*, 9*n*), from the Upper Campanian of Texas, which is also much larger; *M. japonicus* Matsumoto, 1955 (p. 158, pl. 31, figs 1–3; pl. 33, figs 2–3; text-figs 4–5), from the Campanian of Japan; *M. naibutensis* Matsumoto, 1955 (p. 164, pl. 33, fig. 1), from an uncertain horizon in Saghalien, and *M. pusillus* Matsumoto, 1955 (p. 165, pl. 32, figs 1–4), from the Santonian of Japan. Closer is *M. sandai* Matsumoto, 1984 (p. 17, pl. 5, fig. 1; text-fig. 5), from the Upper Campanian of northern Hokkaido, Japan. This is the microconch of *Anapachydiscus fascicostatus* (Yabe, 1921) (which specific name has priority). It has a much more depressed, reniform whorl section than *M. menu*, with whorl breadth to height ratio of up to 1·37, fewer umbilical bullae (9 per whorl, versus 11–13), with stronger ribs, and reaches almost twice the size of the Indian species.

Occurrence. As for types.

Superfamily ACANTHOCERATACEAE de Grossouvre, 1894, p. 22
Family SPHENODISCIDAE Hyatt, 1900, p. 585
[= Libycoceratidae Zaborski, 1982, p. 306]

Genus SPHENODISCUS Meek, 1871, p. 298
[= *Austrosphenodiscus* Olsson, 1944, p. 266]

Type species. *Ammonites lenticularis* Owen, 1852, p. 579 (*non* Phillips 1829, pl. 6, fig. 5), by original designation.

Discussion. See Zaborski (1982, p. 315) and Kennedy (1987, p. 176) for recent discussions of the genus. As noted there, the widely distributed smooth or near-smooth *Sphenodiscus*, described as *S. binkhorsti* (Böhm, 1898) in Europe, *S. lobatus* (Tuomey, 1856) in the United States, Mexico, the Middle East and West Africa, and as *S. siva* (Forbes, 1846) in south India, cannot be adequately compared until larger populations have been described. We suspect that they may well prove conspecific, but cannot prove it. Accordingly, we describe the type material of the oldest named species, *S. siva*, below, but defer decisions on the synonymy or otherwise of other species until new collections from the United States and Nigeria before us are fully analysed.

Sphenodiscus siva (Forbes, 1846)

Plate 15, figs 6–13; Text-fig. 6B, D–E

1846 *Ammonites Siva* Forbes, p. 110, pl. 7, fig. 6.
1850 *Ammonites Siva* Forbes; d'Orbigny, p. 213.
1864 *Ammonites Siva* Forbes; Stoliczka, p. 59, pl. 33, fig. 3.
1895 *Sphenodiscus Siva* Forbes sp.; Kossmat, p. 178 (82), pl. 22 (8), fig. 2.
1908 *Sphenodiscus siva* Forbes sp.; Grossouvre, p. 21, pl. 1, fig. 5.
1977 *Sphenodiscus siva*; Kennedy, text-fig. 31.9–10.
1982 *Sphenodiscus siva* (Forbes, 1846); Zaborski, p. 315.
1987 *Sphenodiscus siva* (Forbes, 1846); Kennedy, p. 176.
1989 *Sphenodiscus*; Kennedy, text-fig. 18*a–b*.

Types. Lectotype, here designated, is BMNH C51087, the original of Forbes (1846, pl. 7, fig. 6; GSC R10481); paralectotype is BMNH C51088, from the Valudavur Formation of Pondicherry, south India (*ex* Kaye and Cunliffe Collection).

Dimensions.	D	Wb	Wh	Wb:Wh	U
BMNH C51087	65·0 (100)	15·0 (23·0)	39·5 (60·8)	0·38	– (–)
BMNH C51088	64·0 (100)	15·0 (23·4)	40·0 (62·5)	0·38	– (–)

Description. Oxycone, with minute umbilicus; greatest preserved diameter 64 mm, whorl breadth to height ratio 0·38. The umbilicus sits in a shallow circumbilical depression. The inner flanks are feebly convex, converging to a sharp venter, the greatest whorl breadth lying well below mid-flank. The surface of the shell, where preserved, is smooth, but for delicate prorsiradiate growth lines, conspicuous close to the umbilical margin only. Suture with shallow incisions (Text-figs. 6B, D–E). E is broad, and shallower than L, which is asymmetrically trifid, and margined by saddles with slender axial zones and phylloid terminations. U has 10 minor lobes in the external part, decreasing in size towards the umbilicus. The first six are asymmetrically trifid and follow a straight, rectiradiate line. Minor saddles on the umbilical lobe have phylloid endings, especially the simpler ones close to the umbilicus. Successive sutures have a tendency to overlap.

Occurrence. As for types.

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